Users Manual

Digital Surge/DC Hipot/Resistance Tester

Models D3R/D3R/D6R/D12R

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Warranty

Baker Instrument Company warrants title to the product and also warrants product on date of delivery to purchaser to be of the kind and quality, merchantable and free of defects in workmanship and material. There are no warranties which extend beyond those expressly stated in this contract.

If within one year of shipment by company of any item of the product, purchaser discovers that such item was not as warranted and promptly notifies company in writing thereof, company shall remedy such non conformance by, at company's option, adjustment or repair or replacement of the item and any affected part of the product. Purchaser shall assume all responsibility and expense for removal, reinstallation, freight, and on-site service in connection with the foregoing remedies. The same obligations and conditions shall extend to replacement parts furnished by company hereunder.

Company's liability to purchaser relating to the product whether or in tort arising out of warranties, representations, instructions, installations, or defects from any cause, shall be limited exclusively to correcting the product and under the conditions as aforesaid.

Any separately listed item of the product (such as tubes) which is not manufactured by the company, shall be covered only by the express warranty of the manufacturer thereof.

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PREFACE

Inside…

- Safety Precautions
- Terms and Symbols
- Warranty Notes
- Authorized Service Centers
- Training Seminars
- Environment
- Shipment

Do Not Touch Test Leads while test is in Progress!

Safety Precautions

Note: The general safety information presented here is for both operating and service personnel. Specific warnings and cautions will be found throughout this manual where they apply.

DANGER

High-voltage test equipment should be handled with CAUTION. High-voltage test procedures should be followed, including the use of high-voltage gloves!

Operation of the tester by persons who are using a pacemaker may present unusual safety risks. Such person should take special precautions!

- Do **NOT** touch the test leads, winding or component under test while a test is being performed. Severe electric shock may result.
- **Never** attempt a two-party operation. Always know what test is being performed and **when.**
- Never attempt to test an energized motor.
- Be sure the surge test instrument is grounded. Use a three lead grounded supply (or an extra ground lead if unsure of supply ground).
- For capacitor start motors or systems with surge arrestors/power factor correction capacitors; be sure to **disconnect** all capacitors from the test circuit **before** testing.
- The surge test is **NOT approved** for use in an explosive environment.
- Upon completion of a DC High Potential test, short the winding, motor, etc., to ground and allow time for discharge before disconnecting the test leads.
- Ensure the tester leads are disconnected before the motor is energized or powered up.
- Do not operate the tester without the covers and panels properly installed.

Power Source Precautions

This product is intended to operate from a power source that does not apply more than nominal 85-264 VAC RMS between the supply conductor or between

Do Not Touch Test Leads while test is in Progress!

either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting the product test leads.

Danger from Loss of Ground

Upon loss of the protective ground connection, all accessible conductive parts, including knobs and controls that may appear to be insulated, can render an electric shock!

Terms & Symbols

- Caution statements identify conditions or practices that could result in damage to the equipment or other property.
- Warning/Danger statements appearing in boxes identify conditions or practices that could result in personal injury or loss of life.
- Notices that are bolded indicate operational cautionary information.
- **Notes:** are important information and hints on the operation of the equipment.

Warranty Notes

Important notice concerning the Warranty and Repairs

The warranty is **Void** if tester is shipped in any container other than the original container it was shipped in **or** factory specified packaging. For replacement factory specified packaging and instructions for proper shipment of the tester see the Shipment section at the end of this chapter. Also, be sure to complete the **Warranty Return Form** when sending the tester to Baker Instrument Company.

If there is a failure of the Baker tester, regardless of whether it is under warranty or not, the customer should **Call the Baker Instrument Company Service**

Department BEFORE returning the unit for repair. In some cases, the repair may be done by the customer at significant savings. If under warranty, the customer may still save costly shipping charges and lost time while the unit is being shipped and repaired. Our service staff may also direct the customer to ship the unit to one of our Authorized Service Centers for repairs.

When calling the Baker Service Department or one of the Service Centers, please have the Model and Serial Numbers (located on the rear panel of the unit) available. If the unit is out of warranty, a purchase order will be required if the unit is returned for repair.

The Baker Instrument Company Service Department phone number is 800-752-8272 or 970-282-1200.

Authorized Service Centers

Europe	Baker Instrument GmbH Hutbergstrasse 21 D-90475 Nurnberg 50 West Germany	49-911-984600 49-911-832169
United States	Baker Instrument Company 4812 McMurry Avenue Fort Collins, CO 80525	970-282-1200 970-282-1010 800-752-8272

Training Seminars

Extensive training seminars are conducted by Baker Instrument Company to help you get the most out of the Surge/Hipot Tester in a wide variety of applications. **In-House Seminars** are available at your site. In these seminars, you can "tailor" the training for your specific needs. Please contact the Sales Department at Baker Instrument Company, 800-752-8272 or 970-282-1200 to schedule an In-House Seminar.

Environmental

The tester should only be operated in temperatures ranging from 0 to 100 degrees Fahrenheit (-17.8 to 37.8 degrees Celsius).

Due to corrosion, humidity will affect the condition of the instrument's components over time. The storage environment of this instrument should be

less than 50% humid. The instrument certainly should not be stored in any location where water entry could occur as the instrument is **NOT** waterproof.

Due to the possibility of arcing in the test leads or in the motor being tested, the D3R/D6R/D12R is **NOT approved for use in an explosive environment**.

Shipment

All Baker testers are shipped using factory foam-filled containers. Should the tester be returned to Baker Instrument Company for any reason, we recommend using the original packaging the unit came in or the following factory specified packaging:

Contact Baker Instrument Company to order factory-specified packaging for your testers. Baker Instrument Company is not responsible for damage due to shipping testers back to the factory in inadequate materials.

List of Items Furnished

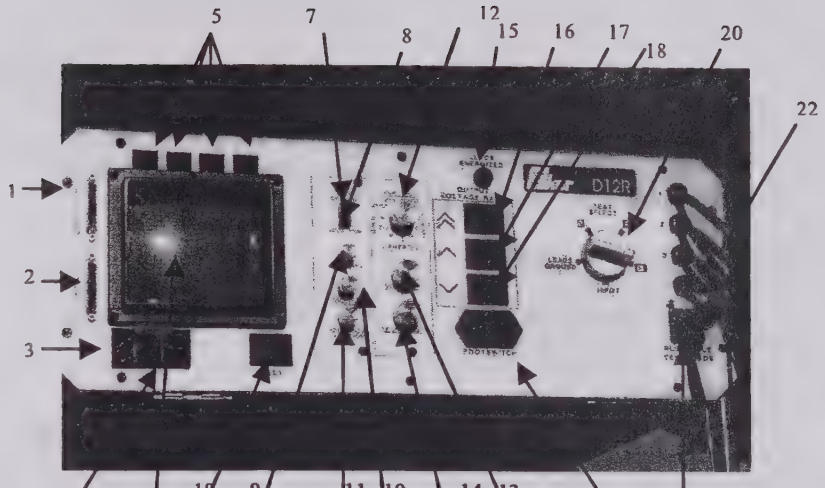
- 1 each – Surge Tester with attached test leads
- 1 each – Removable line power cord
- 1 each – Set of removable Resistance Test Leads
- 1 each – Instruction Manual

CHAPTER 1: INSTRUMENT OVERVIEW

Inside.....

- Front Panel Controls
- Initial Tester Power Up & Checkout
- Using the Footswitch

Do Not Touch Test Leads while test is in Progress!



Digital Front Panel Diagram

Front Panel Controls

1) PRINTER PORT

Parallel port for printing waveforms and summaries displayed by the Digital Tester. This port may also be used for interfacing with the Motor Test Acquisition for Windows program (MTA for Windows) on a personal computer.

2) AUX PORT

Auxiliary port for using the Digital Tester with a 30kV power pack, for high voltage testing. (Refer to Supplement 1: PP130/PP30 Power Pack)

3) LINE IN

AC power entry.

4) ON/OFF

The on off switch for the unit. On/off switch is combined with the AC power entry and a fuse.

5) FUNCTION KEYS

Function keys for data collection, recall, clearing and printing of tests.

6) CRT DISPLAY

The Cathode Ray Tube (CRT) is the location where the tester displays test information. At the Top, menus corresponding to the four function

Do Not Touch Test Leads while test is in Progress!

keys above the CRT are shown. The main portion of the screen displays the waveforms being measured and/or recalled with corresponding graticules for reference. The bottom portion shows the volts/division for the waveform, the name of the test on display, and the micro-seconds/division (micro-amps/division for hipot tests).

7) OPEN GROUND WARNING LIGHT

When the AC line source is not properly grounded, the red Open Ground light will illuminate. The test set will power up, but high voltage will be withheld by internal electronics.

8) HIPOT TRIP WARNING LIGHT

This lamp illuminates to indicate a DC HIPOT trip circuit has stopped the test. The red lamp will stay illuminated until the TEST button is released.

9) INTENSITY

Rotation of this control will adjust the intensity or brightness of the display.

10) VERTICAL POSITION

This control adjusts the up or down positioning of the surge wave pattern. Optimum positioning is usually on the center of one major graticule line below center for surge testing.

11) HORIZONTAL POSITION

This control adjusts the side to side positioning of the surge wave pattern. A trace beginning at the far left is suggested for surge testing.

12) FUNCTION SELECTOR

This control selects the type of test to be performed: Surge Testing, HiPot testing with 4 different current sensitivities, resistance testing for each of the three leads, AT101 testing, and auxiliary/power pack surge/HiPot testing.

- AT101: This position is used when using the Baker Instrument Company Model At101 Bar-to-Bar Armature Test Accessory. **Note**: The Zero Start Interlock is disabled when this function is selected and the FOOTSWITCH is depressed.

- AUX: The auxiliary position is for use with a 30kV Power Pack. The display will also show wave patterns from accessory units in this position.

- Surge: This position selects the Surge Test. The name of the test and the microseconds per division measured is displayed on the lower portion of the CRT for reference. A digital readout for the peak voltage of the test is also displayed in the upper right portion of the screen for reference.

- HiPot- uA/div: This position is used for DC HiPot testing. The name of the test is displayed on the lower portion of the CRT for reference. A digital readout for the leakage current (in micro-amps) of the test and the resultant resistance in mega-ohms is also displayed on the screen for reference. There are four positions associated with the HiPot test. The four positions are 100uA/div, 10uA/div, 1uA/div, and 0.1uA/div. The chosen micro-amps per division setting is displayed on the lower right portion of the CRT for reference during testing. The position of the function knob in one of the above current ranges also automatically selects the overcurrent trip point which will be ten time the settings or 900uA, 90uA, 90uA, or 0.9uA, respectively, for each of the sensitivity ranges above.

- Resistance Lead 1-2: This position selects the storage location for a resistance test. This does not select the actual leads connected to the D12R/D6R.

- Resistance Lead 2-3: This position selects the storage location for a resistance test. This does not select the actual leads connected to the D12R/D6R.

- Resistance Lead 1-3: This position selects the storage location for a resistance test. This does not select the actual leads connected to the D12R/D6R.

13) VOLTS/DIV

This control sets the sensitivity of the display or scale factor in volts per division for both the Surge and DC HIPOT traces. There are four settings corresponding to 500, 1000, 2000, and 3000 volts per division. **Note**: this knob setting does not limit the output voltage of the tester.

14) SECONDS/DIV

This control adjusts the seconds per division or sweep rate of the trace on the horizontal axis of the surge display. There are ten settings corresponding to 2, 6, 10, 20, 60, 100, 200, 500, 600, 1000, 2000

micro-seconds per division. The seconds per division setting is displayed on the lower right portion of the display for the reference during Surge Testing. This control will have the effect of zooming in or out on the wave pattern.

15) LEADS ENERGIZED INDICATOR LIGHT

This indicator light will illuminate when voltage is applied during a test.

16) V FAST UP ⩓

When pressed, this control will increase the applied voltage to a motor at an increasing rate of approximately 1000V/second.

17) V SLOW UP ^

When pressed, this control will increase the applied voltage to a motor at a slower but still increasing rate of 33.3V/second.

18) V SLOW DOWN v

When pressed, this control will decrease the applied voltage to a motor at a slow rate of approximately 250V/second.

19) TEST BUTTON

The TEST button activates the high voltage output of the tester. One of the selected modes, surge or HIPOT, will be enabled and a voltage will be impressed on the device being tested. This button automatically disengages when released and must be held in during the whole length of the test unless the FOOTSWITCH is being used.

20) TEST LEAD SELECT SWITCH

Test Lead Connections

Switch Position	Test Lead #1	Test Lead #2	Test Lead #3	Ground
Surge Lead 1	Hot	Ground	Ground	Ground
Surge Lead 2	Ground	Hot	Ground	Ground
Surge Lead 3	Ground	Ground	Hot	Ground
HiPot	Hot	Open	Open	Ground
All Leads Ground	Ground	Ground	Ground	Ground

21) FOOTSWITCH CONNECTOR

A footswitch may be connected to this socket which is in parallel to the TEST button. The footswitch will operate the tester in a manner

Do Not Touch Test Leads while test is in Progress!

identical to the TEST button, freeing the users hand from having to operate the TEST button.

23) TEST LEADS

Test leads #1, #2, and #3 (red) and grounds (black) are provided for contact to the windings. Test leads are insulated to 45kV.

24) RESISTANCE TEST LEADS

There are two sets of test leads, two wires each lead, that are provided to make contact to the windings of a motor. Each set of leads contains a current carrying lead and a high impedance sense lead.

On-Line Labels

MENU BAR

The Menu Bar presents various options for recalling data, storing data, printing data, and clearing the display.

MESSAGE AREA

Operation and print message are displayed in this area.

WAVE PATTERN DISPLAY AREA/RECORD CHOICE AREA

During testing, Surge wave patterns and DC HiPot potentials are graphically displayed here. Major and minor graticules are provided. During internal memory access, Record and Lead locations are displayed here.

SECONDS/DIV or MICRO AMPS/DIV SETTING

Seconds/division is displayed here during Surge Testing. The micro amps/division setting is displayed here during HiPot Testing.

Initial Tester Power-Up and Checkout

Upon powering up the D3R/D6R/D12R the digital control system begins a self check. Memory is tested, HiPot trips circuits armed, high voltage power supplies disabled, etc. If nothing is visible on the screen, turn the Intensity control to the center of the knob's range. If no image is visible, verify good power is available to the unit and verify the fuses aren't blown.

Each Baker Instrument Company tester incorporates a supply ground detection circuit. The ground detection circuit is active immediately upon power up on

and assures a positive ground is available to the tester. If the instrument is not properly grounded, the OPEN GROUND indicator will light and testing cannot proceed. Check the supply to the tester (broken ground, bad extension cord, excessive ground to neutral voltage) and assure that a low impedance ground is provided to the unit.

If the instrument does not appear to be working properly, contact Baker Instrument Company's Service Department. Refer to Warranty Notes and Appendix B: Troubleshooting for more information.

Using the Footswitch

The Digital tester can be equipped with a footswitch that allows hands free operation of the instrument. For example it is used to help eliminate the display effect of rotor loading, by allowing the operator to spin the rotor of the equipment under test.

Do Not Touch Test Leads while test is in Progress!

CHAPTER 2: RECOMMENDED TEST SEQUENCE, VOLTAGES AND TESTING PRECAUTIONS

Inside....

- Recommended Test Sequence
  - Coil Resistance
  - Megohm Test
  - DC HiPot
  - Surge
- Recommended Test Voltage, IR Values, Leakage Currents
- Applicable Standards

Do Not Touch Test Leads while test is in Progress!

Recommended Testing Sequence

In order to test motors adequately and to have effective predictive maintenance programs, Baker Instrument Company suggests using a specific test sequence. The general idea is to perform the test sequence as a series of progressively more rigorous tests, accepting the idea that if a test fails, troubleshooting and repair should begin at that time. Further, more rigorous testing should only commence after satisfactory diagnosis and/or repair.

The suggested testing sequence is: (1)Resistance test, (2)Meg-ohm, (3)HiPot and finally (4) Surge.

1. Coil Resistance Test

A coil resistance test looks for resistance imbalance between phases, discrepancies between measured resistance values, previous measurements and nameplate values. If a problem is found, the motor should be inspected for the cause of the discrepancies. Typical problems that may exist are 1) hard shorts to the motor's core, 2) hard shorts between coils either within the same phase or between phases, 3) coils rewound with the improper gauge wire, 4) loose or corroded connections. Further HiPot or Surge testing is not necessary until the resistance measurement is acceptable.

2. Megohm Test

A megohm test is performed using a test voltage based on the operating voltage of the motor and the appropriate standards/company testing guidelines. Look for an unusually low megohm value when compared to previous measurements or industry accepted limits for the type of insulation in the motor. If a low megohm value is measured, the motor should be inspected for ground wall insulation damage some part of the ground wall insulation has failed. Possible problems include: 1) slot liner insulation or enamel wire insulation may be burned or damaged, 2) the motor might be full of dirt, carbon dust, water or other contaminates, 3) connections to the actual coils may be bad, 4) wrong insulation may have been used to connect the coils to the motor's junction box, etc. No further testing is necessary until the reason for low megohm readings is found and corrected.

Do Not Touch Test Leads while test is in Progress!

3. HIPOT Test

A HiPot test is performed using a test voltage that is substantially higher than the Megohm Test, but, once again, based on operating voltage of the motor and the appropriate standards/company guidelines. Look for unusually high leakage currents or a leakage current that doesn't stay constant or intermittently jumps up and down. Breakdowns or high leakage currents are an indication of damaged ground wall insulation. Inspect the motor's slot liner, wedges, conductors between the junction box and the coils, etc.

4. Surge Test

A Surge test is performed of each phase of the motor, again using an appropriate test voltage based on the operating voltage of the machine and the appropriate standards/company guidelines. Look for a jump to the left of the surge waveform pattern. This is the signature of the turn – to – turn short. If a jump is observed, an inspection of the motor should be made to look for damaged insulation between adjacent conductors. The insulation may be hard to see visibly, so the motor may have to be disassembled to find the problem. If no jump in the wave patterns is observed, the likelihood of motor failure due to insulation failure is greatly reduced.

Recommended Test Voltage, IR Values, Leakage Currents

Recommended Test Voltages – HiPot and Surge Tests

A recommended test voltage for HIPOT testing a motor, generator or transformer is twice the AC line voltage plus 1000 volts. This test voltage is consistent with NEMA MG-1, IEEE 95-1977 (for test voltage greater than 5000 volts), and IEEE 43-1974 (test voltages less than 5000V).

Examples for 460VAC and 4160VAC motors are as follows:

2 x 460V + 1000V= 920 + 1000 = 1920 V
2 x 4160V + 1000V = 8320 + 1000 = 9320 V

For new windings or rewound motors, the test voltage is sometimes increased by a factor of 1.2 or even 1.7. This provides for a higher level of quality control on the work performed. For the above 460V motor, the test voltage would be:

1920V * 1.2 = 2304
or
1920 * 1.7 = 3264

Note: Although the CRT display is accurately calibrated, it is not possible to set the voltage exactly. It is suggested that the test voltages be rounded off to the nearest graticule discernable on the display.

Applicable Standards

EASA Standard AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus

IEC 60034-1 (1999-08) Consolidated Edition, Rotating Electrical Machines Part I: Rating & Performance Ed. 10.2

IEEE 43-1974 Recommended Practice for Testing Insulation Resistance of Rotating Machinery

IEEE 95-1977 Guide for Insulation Maintenance of Large AC Rotating Machinery

IEEE 112-1991 Test Procedures for Polyphase Induction Motors and Generators

IEEE 113-1985 Guide on Test Procedures for DC Machines

IEEE 115-1983 Test Procedures for Synchronous Machines

IEEE 429-1972 Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-Wound Stator Coils

IEEE 432-1992 Guide for Insulation Maintenance for Rotating Electrical Machinery (5hp to less than 10,000hp)

IEEE 434-1973 Guide for Functional Evaluation of Insulation Systems for Large High-Voltage Machines

IEEE 522-1992 Guide for Testing Turn-To-Turn Insulation on Form-Wound Stator Coils for Alternating-Current Rotating Electric Machines.

NEMA MG1-1993 Motors & Generators

Reprints or EASA standards are available from:
www.easa.com
1331 Baur Boulevard
St. Louis, MO 63132
Phone: 314-993-2220
FAX: 314-993-1269

Reprints of IEC standards are available from:
International Electrotechnical Commission (IEC)
www.IEC.ch

Reprints of IEEE standards are available from:
IEEE Customer Service
445 Hoes Lane
P.O. Box Piscataway, NJ 08855-1331
Phone: 1-800-678-IEEE
Fax: 908-981-9667

Reprints of NEMA standards are available from:
National Electrical Manufacturers Association (NEMA)
Global Engineering Documents
Phone: 1-800-854-7179
International: 303-379-2740

Do Not Touch Test Leads while test is in Progress!

CHAPTER 3: COIL RESISTANCE TESTING

Inside:

- Principles of Coil Resistance Testing
- Resistance Test Display
- Resistance Test Setup
- Resistance Test Checklist
- Description of Auto Ranging
- Saving Measurements to Memory
- Indications of problems in a motor
- Accuracy of Measurements

Do Not Touch Test Leads while test is in Progress!

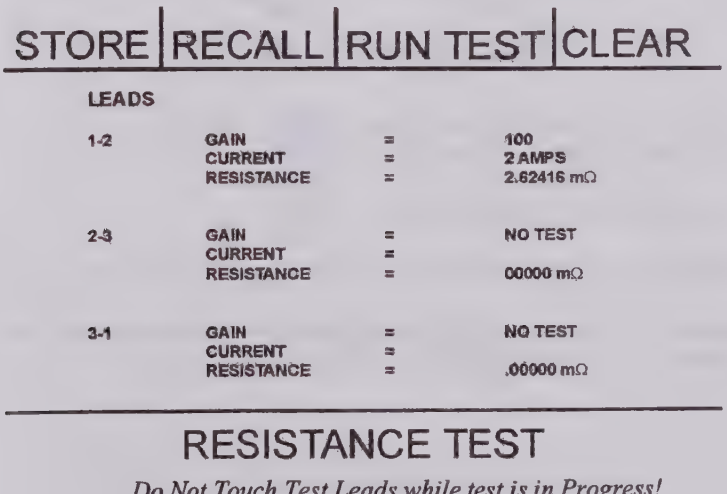
Principles of coil resistance testing

The coil resistance test is a very simple test to perform and is an immediate indication of the health of the conductor(s) in a winding. The coil resistance test consists of injecting a known constant current through the winding, measuring the voltage drop across the winding, and calculating the coil resistance using Ohm's law. If a coil is shorted somewhere in the interior of the winding the resistance will be lower than normal. This lower coil resistance can be compared to previous measurements of the same coil, measurements of identical coils, or compared to the motor name plate value to identify a "bad" coil.

The measured resistance is affected by the variation of copper conductivity with temperature. Therefore, the measured resistance value should be "corrected" to a common temperature, usually 25°C, before comparing two different measurements. MTA for Windows, a data logging application for the D3R/D6R/D12R, does this correction for you.

Since the windings found in many motors have very low resistances, the injected current might have to be as high as 10 amps to accurately measure the voltage drop across the coil. One of the difficulties encountered measuring the voltage drop across the coil itself is, the affect of the contact resistance of the clip leads used to connect to the motor's winding. Contact resistances can be comparable or even greater than the resistance of some coils. The effects of contact resistance are reduced by using a "four wire" or Kelvin measurement. The Baker Instrument uses this technique.

Resistance Test Display



Resistance Test Checklist

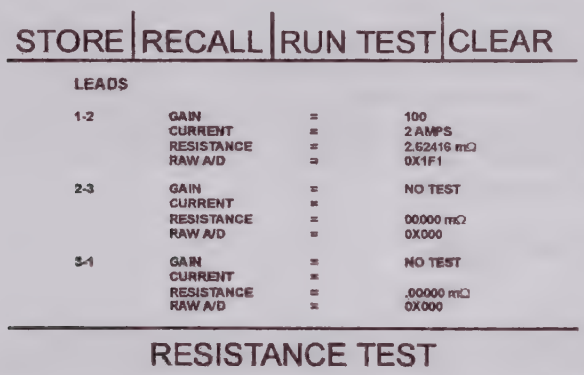
1. Disconnect the high voltage test leads and move them aside. The Baker Instrument resistance test circuitry is protected internally by relays, which ground the resistance test leads when a surge or hipot test is selected. However, the protection relays are in no way rated for any type of live electrical buss or circuit. It is possible to cause severe damage to the instrument if the resistance test leads are attached while surge testing, HiPot testing, or while line voltage is present at the motor leads.

2. Connect the RESISTANCE TEST LEADS to leads 1-2 of the motor.

3. Set the FUNCTION KNOB to the Res 1-2 position.

4. Press the RUN TEST button to start the test.

5. The Baker will begin measuring the coil's resistance using an auto-ranging algorithm described below. The test results will be displayed on the Baker's screen.



6. When the measurement for leads 1-2 are complete, move the RESISTANCE TEST LEADS to leads 2- 3 on the motor.

7. Set the FUNCTION KNOB to Res 2-3.

8. Again, press the Run Test resistance test button again to start the test.

9. Once again, the Baker will make an auto-ranging measurement of the coil's resistance. The result will be displayed on the tester's screen.

Do Not Touch Test Leads while test is in Progress!

10. When the test is complete, connect the Resistance Test leads to leads 3 and 1 of the motor.

11. Set the Function Knob to Res 3-1.

12. Again, press the Run Test button to begin another resistance test.

13. Once again, the Baker tester will make another auto-ranging resistance measurement and the result will be displayed on the tester's screen.

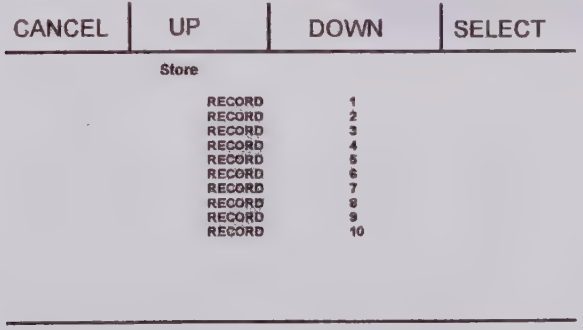
At the end of the test, press the Store button to save the resistance measurements to the Baker's internal memory.

Auto Ranging Resistance Measurement Algorithm

The Baker tester performs an auto-ranging resistance measurement by injecting a current into the coil and measuring the voltage drop across the coil. If the Baker tester does not detect a voltage drop, the current will be raised to 0.2 amps and the voltage drop measured again. If a sufficient voltage is still not developed across the coil, the current will be raised to 2 amps. Once the voltage is detected, the measured voltage will be used to calculate the coil's resistance using Ohm's law. If the Baker tester is still unable to detect a voltage drop after injecting the 2 amp maximum current, the Baker will increase the gain in the voltage measurement circuit until a voltage is detected. If voltage drop still cannot be detected, the tester will indicate 0.000 ohms on the display.

Saving & Recalling Measurements

1. After test is run, select store. The following screen appears.



Do Not Touch Test Leads while test is in Progress!

2. Use the UP and DOWN keys to select the appropriate Record to store the test in.

3. Press SELECT. The tester then displays a clear test screen.

4. To Recall the Record, Select RECALL.

5. The Record screen will reappear. Using the UP and DOWN keys, select the appropriate record.

6. Press Select.

Indications of problems in a motor

If the resistance readings are significantly different from the motor nameplate data or a single lead is more than a few percent different from the others, there is probably a short in one or more of the motor's windings. If one of the values is significantly higher, there could be problems, such as:

1. A loose or corroded wire nut connection.

2. An incorrect amount of turns or an incorrect sized wire gauge used during a re-wind job.

3. An incorrect gauge of cable/feeder used from motor control to motor terminals.

4. Poor or incorrect solder technique used to connect phases.

5. Phases/coil groups connected wrong.

Do Not Touch Test Leads while test is in Progress!

CHAPTER 4: PRINCIPLES & THEORY OF HIGH VOLTAGE DC TESTING

Inside.....

- Principles of Megohm, PI, and HIPOT Testing

Do Not Touch Test Leads while test is Running!

Principles of High Voltage DC Testing

High voltage DC testing of electric motors is performed in order to determine the integrity of the ground wall insulation system of a motor's coil. The ground wall insulation system consists of the wire's insulation, slot liner insulation, wedges, varnish, and sometimes, phase paper.

There are three types of high voltage DC tests performed by Baker test instruments: **Megohm** tests, **HiPot** tests, and **PI** tests. Each type of test is designed to answer a specific question regarding the properties of or the integrity of the ground wall insulation system. There is also a **Stepped HiPot** test that can be performed with Baker testers, but this test does not see widespread use. A brief discussion on each of these tests follows below.

Before going further the meaning of "HiPot test" needs to be discussed. The phrase "HiPot test" is used to describe the general idea of high voltage testing as well as to describe a specific type of high voltage insulation stress test. One must differentiate between the concept HiPot testing and the specific HiPot test based on the context of the discussion.

To perform any of the High Voltage DC Tests, the motor's windings are isolated from ground, the red test leads from the Baker Tester are connected to the motor's three phase coils and the black test lead is connected to the motor's steel core/frame. The output voltage on the red test leads is raised to a predetermined test voltage and the leakage current flowing from the motor's coils, through the ground wall insulation, to the motor frame is measured. The Digital Tester then calculates the resulting insulation resistance (IR) using Ohm's law.

The **Megohm** test is an accurate measurement of the insulation resistance of the ground wall insulation. The test consists of applying a DC voltage, usually 1.7 times the operating "line" voltage of the machine, and measuring the leakage current. The leakage current measurement is taken 60 seconds after the test voltage is reached. The insulation resistance, abbreviated IR, is calculated using Ohm's law:

$$IR = \frac{Applied \quad Voltage}{Measured \quad Leakage \quad Current}$$

The insulation resistance is a function of many variables: the physical properties of the insulating material, temperature, humidity, contaminants on the surface of the winding's insulation, etc. The effects of temperature can be compensated for by converting the IR value to a standard temperature – 40°C as shown later in

this chapter. The effects of humidity and contaminants can not be readily taken into account. Good judgment must be used when analyzing IR values from motors that may be wet, dirty, loaded with carbon dust, etc.

As mentioned above, a suggested test voltage for the Megohm test is 1.7 times the applied/operating line voltage for the motor. For example a 480 volt motor would be tested at 480V*1.7=816VDC. Recommended test voltages can also be found in IEEE 43, ANSI C50.10-1977, IEC 34.1, NEMA MG-1 and EASA technical manuals (see chapter 2).

When first applying the voltage to a motor or when increasing the voltage, an unusually high current is observed. This high current is not a leakage current, but the charging current of the capacitor formed by the motor's copper coils, the ground wall insulation and the motor's steel core. This capacitor is usually called the "machine capacitance".

The **polarization index test (PI test)** is performed to quantitatively measure the ability of the ground wall insulation to polarize. The PI test is the most confusing HVDC test in use due to the subtleties in the interpretation of the results. When an insulator polarizes, the electric dipoles distributed in the insulator align themselves with an applied electric field. As the molecules polarize, a "polarization current", also called an absorption current, is developed that adds to the insulation leakage current. The test results become confusing when attempting to attribute variations in the PI value to the polarizability of the insulator or other affects such as humidity, moisture and instrument error.

The PI test is typically performed at the same voltage as the megohm test and takes 10 minutes to complete. The PI value is calculated by dividing the IR at 10 minutes by the resistance at 1 minute as shown below:

$$PI = \frac{IR(10\,\text{min})}{IR(1\,\text{min})}$$

In general, insulators that are in good condition will show a "high" polarization index while insulators that are damaged will not. IEEE 43 recommends minimum acceptable values for the various thermal classes of motor insulation:

NEMA Class A	1.5
NEMA Class B	2.0
NEMA Class F	2.0
NEMA Class H	2.0

The Baker tester will automatically calculate the PI value at the end of a 10-minute HiPot test. At the test's conclusion, the PI value may be stored in one of the 10 memory locations in the Baker tester for later recall.

Note: Some insulating materials developed in recent years for wire insulation do not readily polarize. For example the newer inverter grade wires do not significantly polarize. As recommended in IEEE 43, if the one minute insulation resistance is greater than 5000Mohms, the PI measurement may not be meaningful. In these situations the leakage current is often very low – almost zero. Such low leakage currents are difficult to accurately measure and as a result, instrument errors become very evident. However, the operator must use judgement before declaring the PI test to be meaningless. The indication of damaged insulation based on the PI test can be a very low leakage current and a low PI value.

The **HiPot** test demonstrates that the ground wall insulation system can withstand a "high" applied voltage without exhibiting an extraordinarily high leakage current or actually breaking down. The test consists of applying a DC voltage to the windings of the machine, same as a Megohm test, but at a higher voltage – usually more than twice the voltage of the machine's operating voltage. Therefore, the HiPot test is often called a "Proof" test. The insulation resistance value at the high applied voltage is not of interest with the HiPot test. However, the value of the leakage current is and, more specifically, whether or not the observed leakage current is within acceptable limits.

The choice of test voltage depends on whether a new motor (or coil) is being tested for acceptance or whether an existing motor is being tested for continued service. Consult your organizations' policies regarding the HiPot test voltage to be used. The simple formula of "2V+1000" generally results in a good test voltage for the HiPot test for motors already in service. Other recommended HiPot test voltages can be found in IEEE 95, IEEE 43, ANSI C50.10-1977, IEC 34.1 and NEMA MG-1 (see chapter 2).

The HiPot test usually lasts one minute and the leakage current recorded at the end of the minute. The leakage current at the end of this minute is to be recorded for future comparisons. Between the time when the voltage is applied to the motor and the time when the leakage current measurement is taken, the operator should carefully observe the leakage current and watch for sporadically varying leakage current that might indicate weak insulation. Such variations should be considered a failure of the insulation.

Do Not Touch Test Leads while test is Running!

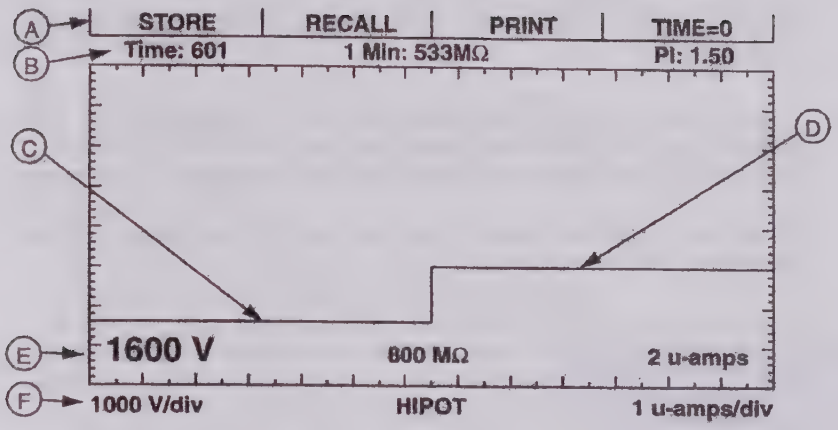
CHAPTER 5: PERFORMING HIGH VOLTAGE DC TESTS

Inside.....

- HiPot Test Display
- HiPot Test Connection
- Hipot Test Precautions
- Hipot Test Checklist
- Using the Footswitch
- Performing a PI Test
- Hipot Over Current Trip Indicator

Do Not Touch Test Leads while test is in progress!

The Test Display



a. Main Menu for Function buttons and Message area.
b. Time duration of Hipot test; Resistance Measurement after one minute; Polarization Index result
c. Voltage Bar
d. Current Bar
e. Digital Output; Resistance Measurement; Current Measurement
f. Volts/Div Setting; Current Test Name; μ-Amps/Div Setting

General User Cautions and Notes

- DO NOT change the TEST LEAD SELECT (TLS) SWITCH while a test is being made. Doing so will cause arcing and damage of the instrument's components.

- Do not switch the FUNCTION CONTROL between Surge and Hipot settings during testing. It is only acceptable to alter Hipot current settings while in the Hipot mode and while no test is in progress.

- When increasing the applied voltage during a test, use a higher Volts/Div setting so the entire trace stays visible on the screen. It is acceptable to change this setting while testing. The Volts/Div control has no effect on and does not limit the output voltage of the tester. It only controls the display scale.

Do Not Touch Test Leads while test is in progress!

- ALWAYS unclip the test leads. Do not jerk or pull them from the motor leads.

- Only touch the test leads with the Test Lead Select Switch in the GROUND POSITION.

- Never connect test leads from two or more testers on the same motor. This includes connection of host and power pack unit leads to the same motor. This warning also includes lead connections, even for grounding purposes.

- Do not connect both the resistance test leads and the high voltage test leads to the motor at the same time.

- Please do not hesitate to contact Baker Instrument Company for technical applications assistance at (970) 282-1200, or toll free at (800) 752-8272. Fax your questions, information, printouts, diagrams, or photographs of your tests to (970) 282-1010. E-mail is also available at www.bakerinst.com.

Test Precautions

Before beginning a HiPot test of any kind, insure that the work area is safe. Remove the line voltage from the motor (the motor is off), insure that there are no power factor correction (PFC) capacitors, noise suppression filters, or surge suppressors in the motor test circuit.

It may be noted that PFC capacitors or surge suppressors may be tested in part with the Baker Tester. See the particular component's manufacturer for more information. If capacitors or surge suppressors are left in place, either the tester will over current trip or the leakage current of the capacitor will be measured along with the motor's leakage resulting in an erroneous measurement of the motor's insulation properties.

If the particular motor is a synchronous type or a DC machine, remove brushes, slip rings, etc. before beginning the test. It is the operator's responsibility to know what is being tested.

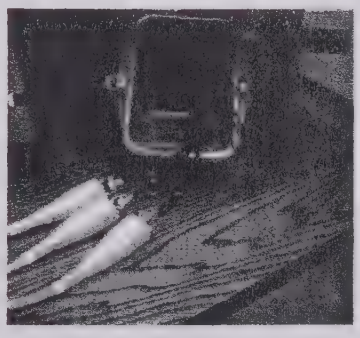
Note: use caution after performing High Voltage DC Tests. Residual charge may still be present on the motor after these tests. **Extreme caution should be taken, this charge can render a sizable shock**. Completely discharge the

motor under test long enough for any residual charge to flow to ground. The required amount of discharge time should be specified by your organization's testing procedures. A widely accepted discharge time is the same time as the duration of the test just completed. Also a good practice is to short the windings of a motor to the motor's core when a motor is not being used for long periods. See IEEE Standards for other recommended times.

High Voltage DC Tests Checklist

Regardless of which type of HVDC test is being performed the following steps should be performed.

1. Verify the work area is safe, the motor is de-energized, and any capacitors (start caps or PFCs) are removed from the motor leads.
2. Disconnect Resistance Test Leads if connected to the motor.
3. Move the Test Lead Selector (TLS) to Ground.
4. Connect the high voltage test leads as shown.
5. Move the Function knob to 100uA/div
6. Determine the test voltage for the motor being tested.



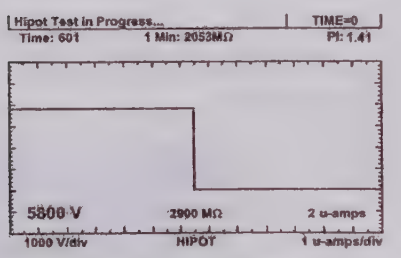
7. Move the Test Selector knob to the HiPot position.
8. Press and hold the TEST button.
9. Press and hold the V Fast Up or V Slow Up buttons until the required test voltage is reached. On large motors with large machine capacitances, the V Slow Up button will have to be used. The V Slow Down and the V Slow Up buttons may be used to make fine adjustments to the test voltage.
10. Press the "TIME=0" soft key to reset the test timer, once the test voltage has been reached.
11. Change the Function knob to the current range that best matches the leakage current being measured by the Baker tester. A message on the CRT will indicate that the current range may be lowered.

Do Not Touch Test Leads while test is in progress!

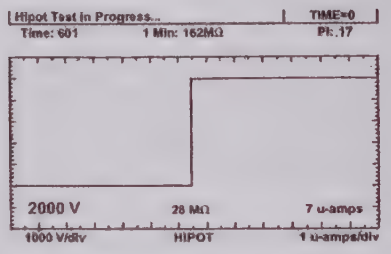
12. Release the TEST button after the required amount of time for the test being performed has elapsed.

13. If desired, the test data may be saved in one of the test records by pressing the "Store" soft key, and selecting the desired test record number and test type.

14. Move the Test Selector knob to the Ground position to discharge the motor. See your organization's guidelines for the required amount of time for leaving a motor grounded after a HiPot test



Good insulation with high voltage and low leakage current.



Poor insulation with low voltage and high leakage current.

Storing the Test Results in Memory

1. Press the "STORE" soft key. A list of available Records appears.

2. Select the desired record to store the data by pressing the function keys corresponding to the UP and/or DOWN to bring the cursor to the desired record and pressing "SELECT".

3. Highlight "HiPot" or "PI" on the CRT screen using the "UP" and "DOWN" soft keys and press "SELECT". The leakage current and applied voltage will be saved in the system's internal memory. The main menu will reappear and the next motor may be tested after grounding the motor for the appropriate amount of time.

Using the Foot Switch

Several of the High Voltage DC tests require the Test button be depressed for long periods of time. To enable hands free operation, a foot switch is available

for use with the Baker tester. The foot switch plugs in the front panel as shown and may be used in place of the test button.

The HiPot Over Current Trip Indicator

The Digital tester is equipped with an Auto-Ranging HiPot Over-Current safety trip. If the Hipot current levels exceed:

- ~900uA in the 100uA/div range,
- ~90uA in the 10uA/div range,
- ~9uA in the 1uA/div range or
- ~0.9uA in the 0.1uA/div range

the over-current trip will remove the high voltage from the test leads, stop the test and illuminate the red HIPOT TRIP lamp on the front panel. Releasing the TEST button resets the trip circuitry, extinguishes the red HIPOT TRIP lamp, and readies the tester for another test.

Effects of Temperature

Temperature has a very strong effect on megohm readings because insulation resistance varies inversely with temperature on an exponential basis. (IEEE 43 has a very good description of this effect.)

Simply put, the insulation resistance drops in half for every 10°C rise in temperature. Therefore, before any judgments are made regarding the health of a motor's insulation based on a trend of past megohm measurements, all the measurements used in the trend should be "compensated" or "corrected" for temperature. The temperature compensation of the insulation resistance means to convert all the IR measurements used in the analysis to the same temperature. The recommended temperature to use is 40°C. The following formula should be used to make the calculation

$$R_c = \left[(1/2) \wedge \left\{ \frac{(40 - T)}{10} \right\} \right] * R_T$$

For example: An insulation resistance/megohm value is 5000Mohms at 30°C, the compensated IR value at 40°C is 2500Mohms.

Performing a PI Test

As mentioned above, the PI test is basically a megohm test that lasts 10 minutes. At the end of the 10-minute test, the Baker tester will automatically calculate the PI value. The PI value can then be stored just like HiPot data. Once again, the motor being tested should be left grounded for quite some time in order to fully discharge the motor windings. The warning is especially appropriate for the PI test as the winding's polarization charge takes quite some time to disappear.

PI Test Procedure:

1. Perform a megohm test using the appropriate test voltage.
2. Continue to press and hold the Test button/foot switch until 600sec/10minutes has elapsed and the Baker Tester shows the calculated PI value in the upper right hand side of the CRT display.
3. Release the Test button/footswitch.
4. Store the PI data, if desired, using the soft keys.
5. Move the Test Selector knob to ground to discharge the motor.

Caution

Upon completion of the HiPot test, allow a sufficient time for the equipment under test to discharge completely. It may take as much as 30 minutes to discharge a motor that has been polarized. Consult your organization's policy regarding discharging times.

Recommended practice is to ground leads of the equipment under test for a time equal to the time the test potential was applied. Use of the GROUND position is recommended.

Do Not Touch Test Leads while test is in progress!

Storing Polarization Index Results

1. After completing the PI test above, press the function key corresponding to STORE. A list of available Records appears.

2. Highlight the desired record number to store the data in by pressing the UP and/or DOWN function keys and press the SELECT function key.

3. Highlight PI in the second column by using the UP and DOWN function keys and pressing SELECT. The Polarization Index value will be stored to the record that is selected. The main menu will reappear and the next motor may be tested.

Step Voltage Test

Another test that can be performed using the Digital tester is the Step-Voltage test. This test is used to indicate the condition of winding insulation by observing the linearity of leakage current as voltage is increased in steps. The best results can be achieved if historical records are maintained of multiple Step-Voltage tests, beginning with measurements made when the winding is new.

Use the same voltage increments and time intervals for all Step-Voltage tests of a particular winding. Baker Instrument Company recommends that you plot out your results on graph paper in order to make comparisons of different tests.

Note: It is important for the insulation to be free of moisture and dirt when this test is made.

Step Voltage Test Procedure

Determine the number of steps you wish to perform, and the voltages and time increments that suit your needs.

For example, if the maximum voltage should be 12,000 volts, you may wish to use six steps of 2000 volts each. The time interval will depend on the capacitance of the test piece and the type of insulation it uses. Choose an interval that lets a noticeable change in resistance readings occur at each step. One minute step intervals are fairly standard or many windings.

Perform a HiPot test on the winding. Refer to DC HiPot test if necessary.

Do Not Touch Test Leads while test is in progress!

Keep the TEST button depressed and record the resistance reading at the first voltage step and time interval. It will be displayed in the lower center portion of the screen.

Continue to hold the TEST button depressed and note the resistance readings for each subsequent step or time interval. Record these results in memory if desired.

For example, with a 12 kV test piece:

1. Connect the motor as usual for a HiPot test.
2. Move the Function Knob to the 100uA/div position.
3. Press the start button and ramp the voltage up to 2000 volts.
4. Move the Function Knob to the best uA/div range for the observed leakage current.
5. At one minute, note the stabilized resistance reading.
6. Move the Function Knob to the 100uA/div setting and increase the voltage to 4000 volts.
7. Change the uA/div range to best match the observed leakage current.
8. At the end of the next minute (2 min after start of test), note the stabilized resistance reading.
9. Again, move the Function Knob to the 100uA/div setting and then increase the voltage to 6000 volts.
10. Change the uA/div knob to best match the observed leakage current.
11. At the end of the minute (three minutes after test start) note the stabilized resistance reading.
12. Again, move the Function Knob to the 100uA/div setting and then increase the voltage to 8000 volts.
13. Change the uA/div knob to best match the observed leakage current.

Do Not Touch Test Leads while test is in progress!

14. At the end of the minute (four minutes after test start) note the stabilized resistance reading.

15. Again, move the Function Knob to the 100uA/div setting and then increase the voltage to 10,000 volts.

16. Change the uA/div knob to best match the observed leakage current.

17. At the end of the minute (five minutes after test start) note the stabilized resistance reading.

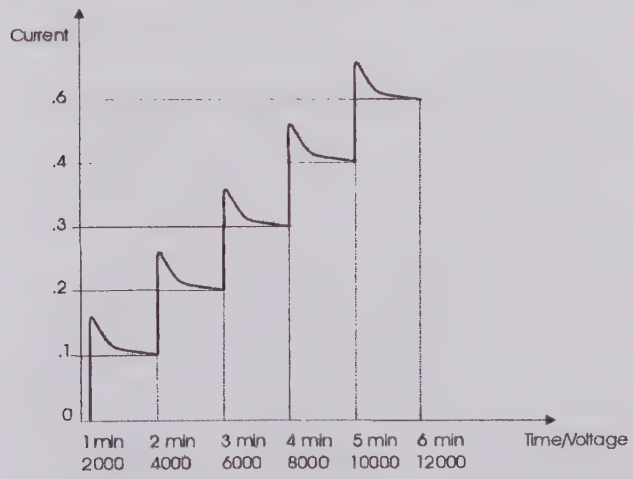
18. Again, move the Function Knob to the 100uA/div setting and then increase the voltage to 12,000 volts.

19. Change the uA/div knob to best match the observed leakage current.

20. At the end of the minute (six minutes after test start) note the stabilized resistance reading.

Note: At each step ramp voltage on the tester in single motions to get the most accurate rise from one test voltage to the next.

When plotted on graph paper, the results should resemble a set of ascending steps. Each step should be flat, indicating a steady resistance value.



Example of Plotted Step-Voltage Test

Do Not Touch Test Leads while test is in progress!

Do Not Touch Test Leads while test is in progress!

CHAPTER 6: PRINCIPLES AND THEORY OF SURGE TESTING

Inside.....

- Principles of Surge Testing
- IGBT Switching Technology

Do Not Touch Test Leads while test is in Progress!

Principles of Surge Testing

Surge testing is performed to detect insulation damage between turns within a motor's winding. This type of insulation problem cannot be found any other way than by surge testing. The surge test consists of applying a short, fast rise time, high current impulse to a winding. This high rise time impulse will induce, via Lenz's Law, a voltage difference between adjacent loops of wire within the winding. If the insulation between the two loops of wire is damaged or somehow weakened, and if the voltage difference between the wires is high enough there will be an arc between the wires. The arc is detected by observing a shift in the surge waveform.

The Surge test is performed with an impulse generator and an oscilloscope type display to observe the "surge waveform" in progress. The surge waveform is a representation of the voltage present across the test leads of the Baker tester during a test. The indication of a turn-to-turn fault is a shift to the left, and/or a decrease in amplitude of the surge test waveform as the test voltage is increased.

Surge Testing Theory

As mentioned above very short high current pulses are applied to the coil during a Surge test to create a voltage gradient (or potential) across the length of the wire in the winding. This gradient produces a momentary voltage stress between turns.

The coil will respond to the surge pulse with a ringing or damped sinusoidal waveform pattern. Each coil has its own unique signature ringing or wave pattern, which can be displayed on a CRT display screen as shown below.

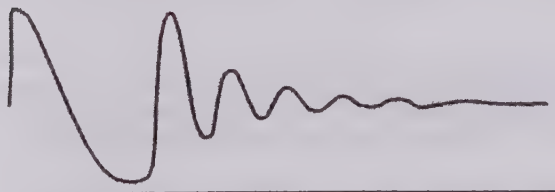


Fig 5.1: Example of a "ringing" wave pattern resulting from Surge Testing

The wave pattern observed during a Surge Test is directly related to the coil's inductance. (There are other factors influencing the wave pattern but inductance

is the primary one.) The coil becomes one of two elements in what is known as a tank circuit – a **LC-type** circuit made up of the coil's inductance **(L)** and the surge testers internal capacitance **(C).**

Inductance (L) of a coil is basically set by the number of turns in a winding and the type of iron core it rests in. The frequency of the wave pattern is determined by the formula:

$$Frequency = \frac{1}{2\pi\sqrt{LC}}$$

This formula implies that when the inductance decreases, the frequency will increase.

A surge test can detect a fault between turns that is due to weak insulation. If the voltage potential is greater than the dielectric strength of the turn insulation, one or more turns may be shorted out of the circuit. In effect, the number of turns in the coil is reduced. Fewer working turns reduce the inductance of the coil and increased the frequency of the ringing pattern from the surge.

The voltage or amplitude of the surge wave pattern is also reduced due to the decrease in inductance of a coil with a fault between turns. It is determined by the formula:

$$Voltage = L\frac{di}{dt}$$

Where the current (i) varies according to pulse time (t)

When the insulation between turns is weak, the result is a low energy arc-over and a change in inductance. When this happens the wave pattern becomes unstable – it may shift rapidly to the left and right, and back to the original position.

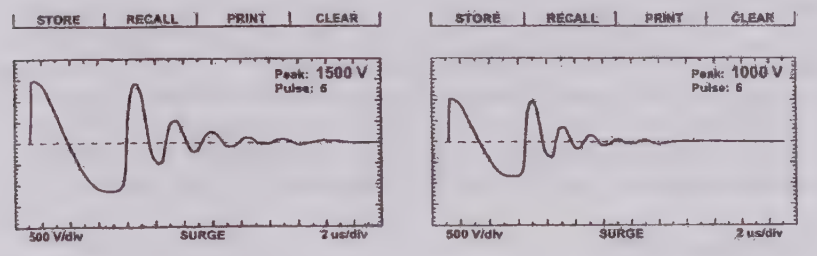
A reduction in inductance occurs due to turn-to-turn faults, phase-to-phase faults, miss-connections, open connections, etc. Partial ground wall testing is also performed in a surge test when there is a ground line to the machine frame.

The Surge test is most often used to test turn-to-turn insulation of coils or single windings. Form coils, start and run windings, and multi-tapped windings are a few examples. Surge tests are also used to compare new windings to a standard winding to assure they conform.

Determination of a Fault

If a fault exists in a motor, the wave pattern on the display will collapse in amplitude and a distinct shift to the left will occur, signifying an increase in frequency (a decrease in inductance). When inductance decreases, the frequency of the wave pattern will increase according to the formula above.

This is illustrated in the figure below. This type of fault is generally one that indicates a failure of the turn-to-turn short.



Good coil

Bad coil

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. It may be desirable to store the wave pattern by this arcing for reference if the operator can release the TEST (this freezes the wave pattern) at the moment when the wave pattern appears the most affected by the fault (reduced amplitude and increased frequency or shift to the left).

Motivation for Surge Testing

Motors are subjected to high energy, high voltage transients in their everyday operating environment. These transient pulses can damage the insulation in the motor and, given enough time, cause a catastrophic failure in the motor. The causes of high energy, high voltage transients are:

- Motor start-up inrush current coupled with **contact bounce** in the MCC.
- **Lightening** strikes in the power system.
- **Inverter drive transients.**

- **Line surges** caused by other motors or transformers tripping in the power system.

One of the primary functions of a Baker Tester is to closely simulate the transient voltages seen by the motor without the high energy that accompanies the normally occurring transients. These spikes are a significant aging factor for the end turn insulation of an electric motor.

Contact Bounce

Oddly enough one of the major sources for the high-energy transients is the MCC, a device that is supposed to protect the motor. When the breaker contacts close in the MCC during startup, they will often "bounce" or chatter, this means that the high inrush current is being made and broken several times. As a result of interrupting the current, an inductive "kick back" voltage spike will be developed. Large inrush currents along with the high inductance of electric motors are what give these "kick back" voltage spikes their high energy.

Lightening Strikes

Lightening strikes can often be present on the power system or grid. Although a great amount of effort is made to protect the grid from the damage caused by lightening, the high voltage transients caused by strikes still get through to motors.

Inverter Transients

Variable speed drives or pulse width modulated drives are based on switching currents very quickly in such a manner that the motor runs at a pre-set speed. The switching of the current combined with the obvious fact that the motor is an inductor result in high-speed transients being generated by the motor drive electronics. These transients are impressed on the motor where they can slowly degrade the insulation in the motor windings.

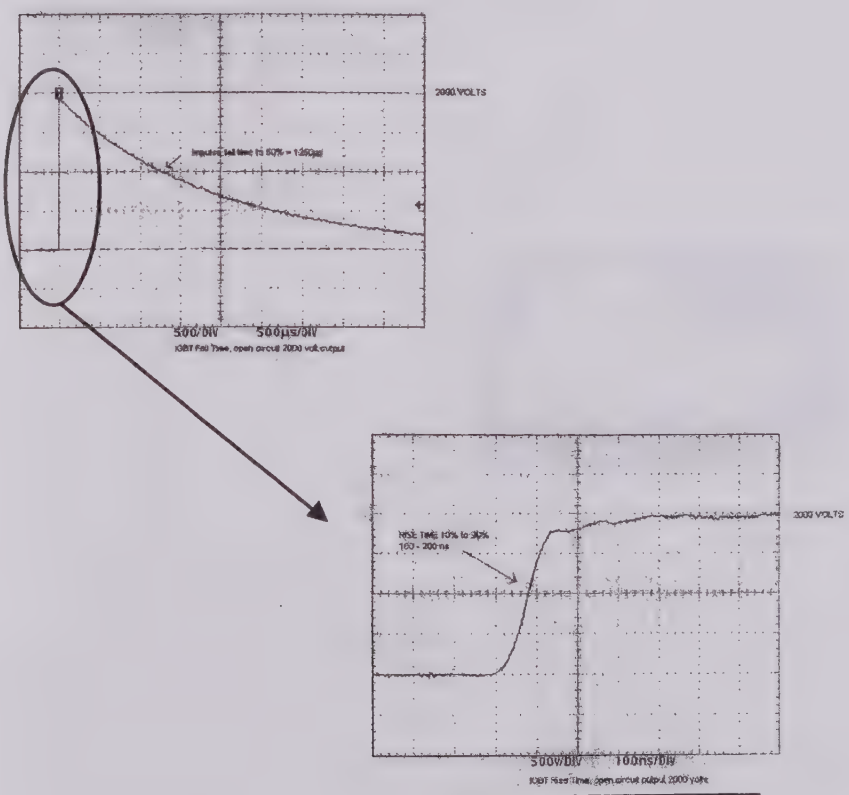
Line Surges

When a transformer or motor operating on a power system trips off line, the energy stored in the motor or transformer has to go somewhere. The energy is either absorbed by the device or is pushed out onto the power system where other transformers or motors have to absorb the energy. Often, large transient voltage spikes manifest this energy impressed on the power system. These

spikes are again, a source of damage to motors, especially if the motor already has weakened insulation.

IGBT Switching Technology

Insulated Gate Bipolar Transistors (IGBTs) are used in the D3R/D6R/D12R surge testers to make a very fast high voltage switch, which is the heart of the surge impulse generator. These IGBT devices are very fast switching transistors. These are often found in variables speed motor drives and are used in the D3R/D6R/D12R in much the same manner as in the drives. However, Baker Instrument Company has uniquely configured many IGBT devices in series to form the high voltage switch. With the fast switching characteristics of the IGBT transistors, the rise time of each surge pulse is between 0.1 and 0.2 micro-seconds.



Close up view of figure above.

Do Not Touch Test Leads while test is in Progress!

Do Not Touch Test Leads while test is in Progress!

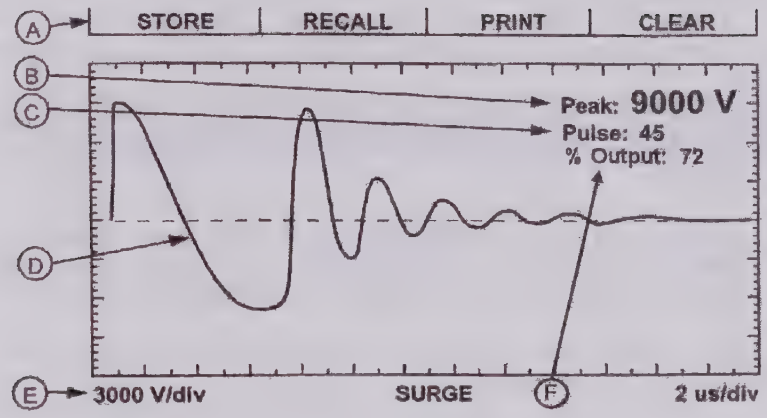
CHAPTER 7: PERFORMING SURGE TESTS

Inside.....

- Surge Test Display
- Surge Test Setup
- 480V 3 Phase Motor Check List
- Single Coil Surge Test and Setup

Do Not Touch Test Lead while test is in Progress!

Surge Test Display



a. Main Menu
b. Digital Peak Voltage Readout
c. Number of surge pulses applied to the test winding
d. Example of a surge wave pattern
e. Volts/Div Setting, current Test Name, Seconds/Div setting
f. % output

General User Cautions and Notes

- Irregularities, particularly vertical spikes, may be seen the first cycle of the surge wave pattern. Therese occur most frequently on large, high voltage motors. Do not interpret these as faults in the windings. Any winding fault will be seen throughout the entire wave pattern.

- DO NOT change the TEST LEAD SELECT (TLS) SWITCH while a test is being made. Doing so will cause arcing and damage of the instrument's components.

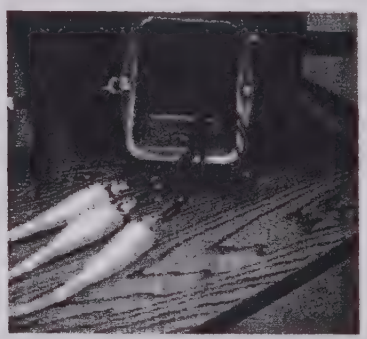
- Do not switch the FUNCTION CONTROL between Surge and Hipot settings during testing.

- When increasing the applied voltage during a test, use a higher Volts/Div setting so the entire wave pattern or trace stays visible on the screen. It is

acceptable to change this setting while testing. The Volts/Div control has no effect on and does not limit the output voltage of the tester. It only controls the display scale.

- ALWAYS unclip the test leads. Do not jerk or pull them from the motor leads.
- Only touch the test leads with the Test Lead Select Switch in the GROUND POSITION.
- Never connect test leads from two or more testers on the same motor. This includes connection of host and power pack unit leads to the same motor. This warning also includes lead connections, even for grounding purposes.
- Do not connect both the resistance test leads and the high voltage test leads to the motor at the same time.
- Please do not hesitate to contact Baker Instrument Company for technical applications assistance at (970) 282-1200, or toll free at (800) 752-8272. Fax your questions, information, printouts, diagrams, or photographs of your tests to (970) 282-1010. E-mail is also available at www.bakerinst.com.

Surge Test Setup



1. Connect the motor as shown in one of the figures above. Connect phase 1 to Test Lead 1, phase 2 to Test Lead 2, phase 3 to Test Lead 3, and the motor core to the black ground lead.

Do Not Touch Test Lead while test is in Progress!

Note: these connections are the same as for the HiPot tests of Chapter 5. To HiPot and Surge Test a motor, the test leads only need to be connected once. The position of the Test Lead Selector Switch determines which lead is "hot" and which lead is held at ground. The table below details the test lead configuration for each of the positions of the Test Lead Selector Switch:

Switch Position	Test Lead #1	Test Lead #2	Test Lead #3	Ground
Test Select 1	Hot	Ground	Ground	Ground
Test Select 2	Ground	Hot	Ground	Ground
Test Select 3	Ground	Ground	Hot	Ground
HiPot	Hot	Open	Open	Ground
All Leads Ground	Ground	Ground	Ground	Ground

After connecting the motor to the test leads, rotate the Function Knob to the Surge position. The CRT display should look like the one shown below.

Note: the "Surge" message at the bottom of the display indicates a normal surge test is active (and not an AT101 type test or a power pack test).

Before beginning the test, insure that there are no power factor correction capacitors or surge suppressors in parallel with the motor. Power factor correction capacitors will reduce the effectiveness of the surge test while surge suppressors will shunt to ground the surge signal. It is the responsibility for the operator to know what is being tested.

It is the responsibility of the operator to insure that the work area is safe.

Once the area is clear and safe, press the "Test" button to start the test. Press the voltage control buttons to ramp the test voltage up or down. As the voltage increases watch the waveform for sudden jumps to the left which indicates a turn-to-turn short.

The test should conclude once a predetermined test voltage is reached. Consult IEEE 522, NEMA MG-1 for recommended test voltages. A good rule of thumb is to test a coils at 2*V+1000 where V is the operating voltage of the motor. Examples: a 480 volt motor would be tested at 2*480+1000=1960V, a 4160 volt motor would be tested at 2*4160+1000=9320V.

Do Not Touch Test Lead while test is in Progress!

480V Three Phase Motor Check List

Check to ensure there is nothing connected to the coil or winding being tested. This is extremely important when testing installed coils or windings. Test inaccuracies will result and the situation can be hazardous to personnel performing tests.

1. Plug the unit in and insure that there is a good ground connection. The unit will illuminate the Open Ground detect light and inhibit testing if a positive ground is not sensed.

2. Move Test Lead Switch to Ground.

3. Connect the three-phase motor as shown.

4. Calculate final test voltage.

5. Rotate the Function Knob to Surge.

6. Rotate the test selector knob to Lead 1.

7. Press and hold the Test button. The instrument is now generating surge pulses and the waveform is shown on the display. The trace for the waveform may be moved up and down and left and right using the Horizontal and Vertical position controls on the front panel. The display will show the measured maximum voltage across the terminals of the motor, number of applied pulses, and the % output of the tester along with the waveform.

8. Press the Output Control buttons to increase the applied surge voltage.

9. Adjust the Volts/div scale and the Time/div scale to fit the surge waveform on the screen. The Volts/div scale may have to be changed as the test proceeds to higher test voltages.

Example: For a test voltage of 2000V, a Volts/Div setting of 500 will give a wave pattern with 4 divisions of amplitude that does not go off the screen. For a test voltage of 4000V, a setting of 500 Volts/Div would result in a wave pattern with 8 divisions amplitude which would go off the screen.

Do Not Touch Test Lead while test is in Progress!

10. Watch the surge waveform display while the voltage is increasing looking for flickering display, a drop in amplitude or a jump of the waveform to the left of the display.

11. Once the test voltage of 1960V is reached, stop pressing the output control button and release the Test button.

12. Store the results for Lead 1 in one of the 10 test records with the following procedure:

    a. Press the store Function Key above the top of the screen.

    b. Select the record you wish to store the data in by pressing the Up / Down Function Keys to highlight the desired record and pressing Select.

    c. Highlight Lead 1 on the next screen.

    d. Again press select to load the data into the tester's memory.

10. Move the Test Lead Selector Switch to Lead 2.

11. Repeat steps 5 through 8 for lead 2, and save the data in the tester's memory as was done in step 9.

12. Move the Test Lead Selector Switch to Lead 3.

13. Repeat Steps 5 through 8 for Lead 3 and again save the data in the testers memory as was done in step 9.

Note: A good way to check the wave patterns after the test is complete is to display all three wave patterns at once. To do so, press the function key that corresponds to Recall. Press the Up and/or Down keys to bring the cursor to the desired Record and press the key that corresponds to Summary. Stored data for all three lead locations appear on the display along with any recorded HiPot data.

Do Not Touch Test Lead while test is in Progress!

Single Coil Surge Test and Set-Up

Note: Check to ensure there is nothing connected to the coil or winding being tested. This is extremely important when testing installed coils or windings. Test inaccuracies will result and can be hazardous to personnel performing tests.

1. With the TEST LEAD SELECT (TLS) switch in the LEADS GROUND position, make the following connections. Refer to the Test Lead Connections table present earlier in this chapter for lead information.

   a. Connect lead #1 on one side of the coil or winding.

   b. Connect test lead #2 to the other side of the coil or winding.

   c. Connect the black Ground lead and test lead #3 to the frame or housing of the coil or winding.

2. Turn the FUNCTION switch to the Surge position.

3. Select TLS position #1. This lead will be HOT.

4. Set the VOLTS/DIV switch at the lowest setting that will allow the maximum pattern to be viewed entirely on the CRT.

   Example: For a test voltage of 2000V, a Volts/Div setting of 500 will give a wave pattern with 4 divisions of amplitude that does not go off the screen. For a test voltage of 4000V, a setting of 500 Volts/Div would result in a wave pattern with 8 divisions amplitude which would go off the screen.

5. Depress and hold the TEST button (or FOOTSWITCH).

6. Press Up or Fast Up switch. Apply voltage to the test windings. Monitor the trace on the display and adjust the Volts/Div and Seconds/Div controls to get the best waveform. Release Up or Fast Up when voltage is reached.

7. Adjust the OUTPUT and VOLTS/DIV controls to the desired voltage level while maintaining a fully visible wave pattern on the CRT display. The

Do Not Touch Test Lead while test is in Progress!

voltage is measured from the zero line to the first positive peak (at the far left) of the trace multiplied by the display VOLTS/DIV setting. The peak voltage is numerically displayed in the upper right portion of the Surge Test display.

8. When the test for the lead is complete, the TEST button may be released.

9. If the surge wave pattern appears steady and stable, the winding insulation is sufficient to withstand the applied voltage and the test is successful.

   Note: If the wave pattern begins to flicker or rapidly ship to the left and right and/or up and down as the OUTPUT is increased, there is weakness in the winding insulation and intermittent arcing between the windings or phases. The winding or phase contains a fault when the wave pattern shifts to the left and the amplitude drops. The more severe the shift and amplitude drop, the more severe the fault. Faults are often accompanied by an audible arcing sound.

   When an obvious fault is present, perform **Step 7** below. End the test by disconnecting the motor from the tester.

10. Store the test results in the tester's memory.

    a. For testing a single coil or for standards testing, store the pattern using QUICK STORE.

       1. Press the function key corresponding to STORE. A list of available records and leads appears.

       2. Press the key corresponding to QUICK STORE. The wave pattern is now stored in Record #1, Lead #1 and is immediately recalled on the screen.

    b. Store the pattern conventionally if the tests are to be downloaded to a pc for further analysis.

       1. Press the function key corresponding to STORE. A list of available records appears.

       2. Press the keys corresponding to the UP and/or DOWN to bring the cursor to the desired Record. Press SELECT.

       3. Repeat step 2 above for the desired lead.

Do Not Touch Test Lead while test is in Progress!

Note: The flicker in wave patterns that is observed when there is arcing between the windings or phases cannot be stored in the Digital tester. As soon as the TEST button is released, the wave pattern freezes. This is the only wave pattern that can be stored.

It is desirable to store the wave pattern production by this arcing for reference. The operator must attempt to release the TEST (thus freezing the wave pattern for storage) at the moment when the wave pattern appears the most affected by the fault (reduced amplitude and higher frequency).

11. Change the TLS to position #2 and test again.

NOTE: It is convenient to store the results of a single motor into a single Record. Store the two wave patterns for the coil into two Lead locations for the desired Record. The results of up to ten motors can be stored on the Digital tester.

In summary, for each direction the coil is tested, check the display for the wave pattern produced in each test. If there are two good stable patterns, the winding is good. If you see anything other than good patterns, there is a possible fault. Refer to the chapter on Determination of a Fault for explanations of wave patterns indicating good or faulty windings. For determination of wave patterns for a variety of devices refer to Surge Test Applications. Keep in mind, fault determination is often a result of experience.

Example: Comparison to a Master Coil

Occasionally, a manufacturer may want to test against a standard. The selected standard coil is surge tested, results are stored in memory and recalled to the screen. Quick store is useful for this situation. All unknown coils would be tested and compared to the standard coil's wave pattern. Standards testing demonstrates the coils ability to withstand minimum test voltages and the signature waveform can be compared to the standards single waveform.

CHAPTER 8: SURGE TEST APPLICATIONS

Inside.....

- Maintenance Testing
- Single Phase Motors and Two Terminal Divices
- Form Coils
- Three Phase Motors
- Two or More Single Coils
- Wound Rotor Motors
- Synchronous Motor/Generator
- DC Motor/Generators
- Field coils
- Chiller Motor Testing
- Armatures
- Testing Large AC Stators/Motors
- Rotor Loading (coupling) when Testing Assembled Motors
- Testing Assembled Motors from the Switchgear
- Transformers

Do Not Touch Test Leads when Test is in Progress!

Note: For additional reference for fault determination see Typical Winding Faults.

NOTE: If all three wave pattern comparisons in surge testing show considerable separation when testing three phase windings, the motor has a Phase-to-Phase short.

Maintenance Testing

Baker Instrument Company Surge Testers have become extremely popular for industrial maintenance programs, troubleshooting, and to ensure that replacement motors (spares, reconditioned motors, or rewinds) are thoroughly tested. The following are guidelines for performing surge tests on assembled motors in the field as part of maintenance testing.

Hard-shorted winding faults are rarely found in motors during maintenance testing. Solid turn-to-turn winding faults happen when the insulation on adjacent copper wires has failed to the point that adjacent wires are welded together. It is a rare condition in maintenance testing because of a transformer action which occurs within the windings which induces very high current in a hard turn-to-turn short. The high current causes heating and deterioration of the surrounding insulation systems. The single turn-to-turn short rapidly compounds until the damage causes a failure in the ground wall insulation. The high current will trip the circuit breaker and stop the motor. A solid turn-to-turn, or hard-shorted winding fault is not the type of fault to expect to see during maintenance testing. This condition is usually only found after the motor has failed.

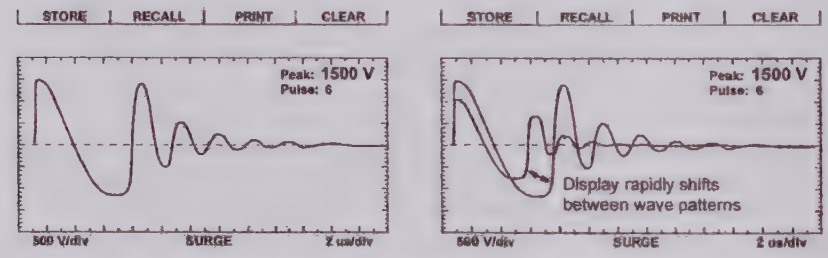
During surge testing, steady separation in the wave pattern comparisons is most often the result of the rotor coupling with the stator. (See Rotor Loading (Coupling) when testing Assembled Motors). In this case, a consistent double wave pattern will be seen at all voltage levels. Separation due to rotor coupling should ***not*** be interpreted as a fault.

The key to the surge test for maintenance is to detect a fault at a voltage level above the peak operating voltage but not above what the motor would withstand during start-up. For example, a 460V motor that shows a good trace at 500V but shows an unstable, flickering patter, (regardless of rotor coupling) at 1500V definitely contains a fault. When the fault is detected above operating voltage, time is available to schedule service for the motor before a hard short and rapid failure occurs.

Consider a 460V AC motor. The operating voltage is the root mean square, a kind of average, of the AC power supply. For this motor, multiply 460V by 1.4 to determine the maximum voltage level that the coil undergoes during normal operation. It is approximately 650 volts. Suppose the motor has an insulation fault at 500 volts. This motor will probably fail while in service well before it can be surge tested because the peak of the AC voltage will continuously stress the fault under normal conditions.

The goal, therefore of the surge test is to detect weakness well above the operating voltage of the motor, as much as twice the operating voltage plus 1000 volts. Refer to Recommended Voltages for a thorough description of how to determine test voltages along with IEEE references that explain the reasons for these recommendations.

As shown in the figures below, a good winding will produce stable wave patterns from zero volts up to the recommended test voltage. Faults will be detected during surges tests are unstable, flickering wave patterns that appear as the voltage is increased.



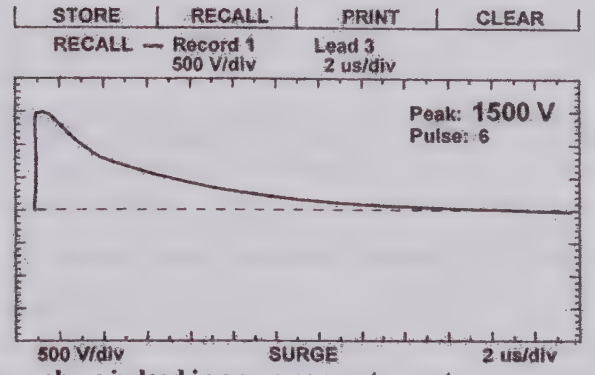
Good wave pattern (left) and a representation of how a "live" wave pattern may appear to move on the display for a winding or coil that contains an intermittent short or is arcing (right).

Application Notes

- If an open circuit is indicated, check the connections between all three test leads and the device under test.

- Check for open test leads at the clip end. With heavy use test leads should be checked weekly to ensure there is no breakage. Test leads are easily

checked by firmly grasping the boot and clip in one hand while pulling on the lead with the other. A broken lead will stretch. A good lead will not stretch.



Open phase in lead in a wye-connector motor.

Single Phase Motors and Two Terminal Devices

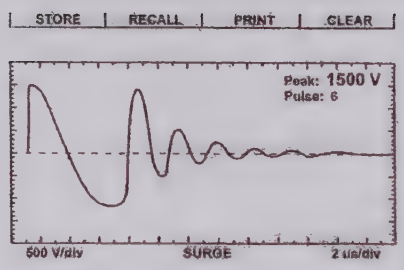
Select TLS #1 and connect the corresponding test lead #1 to one side of the device. Connect test lead #2 to the opposite side of the two terminal device. Connect the ground lead and test lead #3 of the tester to the frame or metal core material.

Determination of a Fault

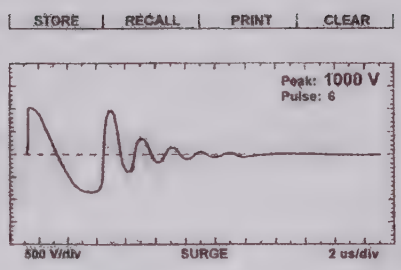
If a fault exists in a single phase motor or two terminal device, the wave pattern on the display will collapse in amplitude and a distinct shift to the left will occur, signifying an increase in frequency (a decrease in inductance). When inductance decreases, the frequency of the wave pattern will increase according to the formula:

$$Frequency = \frac{1}{2\pi\sqrt{LC}}$$

This is illustrated in the figure below. This type of fault is generally one that indicates a failure of turn-to-turn insulation.



Good Coil



Bad Coil

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the TEST (this freezes the wave pattern.) at the moment when the wave pattern appears the most affected by the fault (reduced amplitude and increased frequency or shift to the left).

Form Coils

Form coils should be tested similarly to a two terminal device (see Single Phase Motors and Two Terminal Devices). The Surge test is recommended for form coil testing because it alone can generate the turn-to-turn voltage that is required in these low impedance coils.

Determination of a Fault

Refer to the previous section on Single Phase and Two Terminal Devices to determine if a fault is present.

Notes and Tips for Form Coils

- IEEE-522-1992 recommends a test voltage for Vacuum Pressure Impregnation coils, before they are cured, of 60-80 percent of the test voltage of fully cured coils.

- Currents required to test form coils often limit the maximum surge voltage. Placement of the coils into the stator iron or spare laminations has the effect of enabling the tester to produce a higher voltage drop across the coil for a given current level.

- CAUTION should be exercised since the laminations or stator core have induced voltage on them, and can provide a path or ground.

- Many formulas are used in calculating a test voltage for AC form-wound coils. These are generally based on experience and theoretical arguments about the distribution of voltage in a coil and the entire winding. Some of these formulas are difficult to apply because of the great diversity of coil specifications and characteristics. One popular formula (based on Paschen's Law) states a minimum and maximum test voltage range:

  Minimum = Number of turns x 500 Volts
  Maximum = Winding operating voltage x 1.5

  The minimum voltage would be necessary to show a void in the turn insulation that would result in arcing. The maximum voltage value is based on the worst case distribution of a surge in the winding. Studies (IEEE-522-1992 and IEEE-587-1980) have shown that a very rapid surge from a lightning strike or contactor closing/opening may be distributed across the first coil of a winding.

Three Phase Motors

Wave patterns for three phase windings are compared in pairs. The storage capabilities of the Digital Tester allow all three phases to be compared without removing and reconnecting the test leads. The operator simply recalls any one of the previously tested leads. Baker Instrument Company recommends the following procedure:

1. Connect the three numbered RED test leads to the three winding legs.

2. Connect the BLK GRD lead to the frame or core of the winding.

3. Begin with the TLS in position #1. This indicates lead #1 will be hot while leads #2 and #3 provide a ground path for the surge impulse.

Do Not Touch Test Leads when Test is in Progress!

4. Perform the test as described in Three Phase Motor Surge Test and Set-Up.

For each test, you will have checked the display for a wave pattern. Recall a SUMMARY from the digital tester's memory the wave patterns for the motor for comparison. If you see three good wave comparisons, there is every indication to believe the motor is good. If you have seen anything other than good patterns, there is a possible fault.

Determination of a Fault

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the Test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

Separation in two of three wave pattern comparisons indicates incorrect turns count. The fault will be in the phase connected to the test lead in common between the two comparisons which show the separation for wye-connected windings.

In the Repair Shop: separation of compared wave patterns on Stators indicates a hard fault, such as a solid turn-to-turn or group-to-group short, an incorrect turns count, or misconnections.

In the Field: In assembled motors, separation of the wave patterns is often the effect of rotor coupling, also known as rotor loading (see Rotor Loading (Coupling) when Testing Assembled Motors).

Two or More Single Coils

Surge testing can be used to test two or more identical single coils separately and then compare their wave patterns against each other.

1. Connect test lead #1 to one side of coil #1 and connect the ground test lead to the other side.

2. Connect test lead #2 to the second coil or identical coils and connect test lead #3 to that coil's other side.

3. Surge test the first coil with the TLS in position #1. Store the results in memory.

Note: Use Quick Store for a fast determination of the results of the test.

4. Surge test the second coil or any number of identical coils with the TLS in position #2. (Store the results if desired).

If the wave patterns are stable and they superimpose on the display, the two windings are identical. They have no faults and the insulation of both coils is good.

Determination of a Fault

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the Test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

Separation of the wave patterns when compared indicates incorrect turns count. The fault will be in the coil connected to the test lead which produces the wave form most shifted to the left and collapsed in amplitude.

Notes and Precautions for Two Single Coils

- All windings or magnetic material (iron or ferrite) close to the coils under test MUST BE THE SAME for both coils. For example, if DC fields coils are being tested, both should have the pole pieces inserted or both removed. A coil on a table when compared to an identical coil in the frame will show separation of the wave patterns because inductance differs in iron and air.

- Slight variations in magnetics of the tested device can result in similar coils not comparing identically. An example of this is synchronous pole pieces, one of which is making better magnetic contact with the rotor then the comparing pole. For this reason it is recommended that devices like pole pieces be evaluated individually and Not compared.

- Paschen's Law states that a voltage greater than 334 volts is required to initiate an arc between two conductors in air. This would suggest a minimum voltage for surge testing to be greater than 334 volts. Because of the sometimes non-linear distribution of the surge pulse, it is recommended that a minimum surge potential of 500 volts be used when testing a two terminal device.

- Shunt coils often have a small error in turns count. Some mismatch or separation of patterns should be acceptable. If the wave patterns are very close in shape and remain stable during the test, the coils generally are acceptable. In addition, winding tolerances on single coils may allow for differences in turns count which causes a slight, steady separation. The operator should investigate whether this condition is acceptable or not.

- A slight imbalance (separation) may be noticed if the windings are not correctly phased: ie: the winding configuration of one compared to another is clockwise verses counterclockwise. Try reversing one set of test leads connections and repeating the test before rejecting the winding.

- Many two terminal devices have very high turns count. The waveform displayed is similar to that of an OPEN circuit. In this case, the impedance of the coil is too high to be tested. Double check for poor connections and test lead breakage to see if these conditions may be causing the apparent open condition.

Wound Rotor Motors

Wound rotor motors are tested as though they are two separate three phase windings where one is the stator and the other is the rotor. Procedures to successfully test the wound rotor motor are as follows.

1. Remove the brushes touching the slip rings.

2. Short together the slip rings with jumpers. The jumpers minimize the coupling effect between rotor and stator.

3. Surge test the stator as would be done on a three phase induction motor. See Three Phase Motors or follow the directions in Three Phase Motor Surge Test and Setup.

NOTE: Since the rotor is shorted out there will be no chance for a high induced voltage transformed from the stator to damage the rotor.

4. To surge test the rotor, disconnect the jumpers from the slip rings. Connect the tester test leads to the rotor slip rings.

5. Short together the stator leads with jumpers, as done for the rotor.

6. Repeat Step 3 for the rotor.

NOTE: Check the motor name plate for rotor voltage to calculate the rotor test voltage level. Rotor Voltage is **not the same** as the stator voltage.

If the wave patterns are stable and they superimpose on the display, the windings are identical. They have no faults and the insulation of both coils is good.

Determination of a Fault

If any wave pattern become erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. It may be desirable to store the wave pattern produced by these arcing for reference if the operator can release the Test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

Separation of the wave patterns when compared indicates incorrect turns count. Interpret the separations as for three phase motors.

Synchronous Motor/Generator

The synchronous stator is tested as a three phase induction motor. The rotating fields should be tested individually.

1. Before surge testing the stator.

    a. Remove the DC Leads to the brush boxes or lift all of the brushes off the slip rings.

    b. Short the slip rings for the rotating fields together.

2. Surge test the stator following the procedures and steps for Three Phase Motors.

3. Individual poles are surge tested as outlined in the procedures for testing Single Phase Motors and Two Terminal Devices. The recommended test voltage is 600 volts per pole. It is not necessary to disconnect the pole piece leads before testing.

4. The Hot and Ground leads are then reversed and the test repeated on each coil.

If the wave patterns are stable and they superimpose on the display, the windings are identical. They have no faults and the insulation of both coils is good.

NOTE: One field can be tested and its surge wave pattern can be stored for reference. The other fields can then be compared to this reference pattern in a procedure that is similar to that of Two or More Single Coils.

Determination of a Fault

Two types of faults may exist in synchronous motors and generators.

Pole Piece Fault

Do not expect coils to compare exactly. Rotating fields or pole pieces are often not wound to identical, exacting standards. If a fault does exist in the pole pieces of the test, the wave pattern on the display will collapse in amplitude and a distinct shift to the left will occur, signifying an increase in

frequency (a decrease in inductance). This type of fault is usually failure of the turn-to-turn insulation.

Stator Winding Fault

For a stator winding fault, if the wave pattern changes and becomes erratic during the test, then intermittent shorting or arcing is occurring in the winding under test. Steady separation of the wave patterns of the phases when recalled and compared indicates solid shorts. (See Three Phase Motors).

Chiller Motor Testing

Before applying any test potential to a chiller motor, please review the manufacturer's instructions. These instructions usually recommend bleeding the vessel to atmospheric pressure before applying a test potential.

Surge test procedures for chiller motors follow those outlined for Three Phase Motors.

Field Coils

When testing field coils follow the procedures outlined for testing Single Phase Motors and Two Terminal Devices and Synchronous Motor/Generator. The recommended surge test voltage for DC fields is 600 volts.

If the impedance of the coils is very low (few turns count, generally form coils with very low resistance) the surge tester stand-alone may not adequately test the coils. A bar-to-bar, low impedance test accessory from Baker Instrument Company will be necessary.

DC Motor/Generators

While the series or shunt fields of the DC motor/generator are tested as a two terminal device, the armature may be tested by three different methods. A short armature testing video is available at no charge from Baker Instrument Company.

Armatures

There are two methods of surge testing armatures: the Bar-to-Bar surge test and the Span surge test. The use of a Footswitch is highly recommended to ease the operation of these tests.

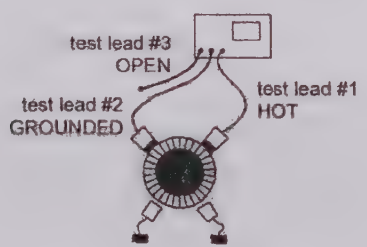
Bar-to-Bar Surge Test

Bar-to-Bar armature surge testing is the most effective method to test DC armatures and detect winding insulation weaknesses and faults. In many cases, where the impedance of the coils in the armature is very low, it may be the only method possible to test the armature.

To perform bar-to-bar Surge testing, the Model AT101D Bar-to-Bar testing accessory is necessary. Bar-to-Bar testing instructions accompany the AT101D and can be found in Supplement 3: Model AT101D Bar-to-Bar Armature Test Accessory in this manual.

Span Testing

This method uses the brushes of the assembled DC motor to make the connections with the commutator for testing of the armature. Any number of bars can be used in this test. Either adjacent bars can be surge tested or a specific number, or "span" of bars can be tested. The number of bars tested in each span for an individual motor must be the same during the entire test. In the repair shop, a fixture can be used in place of the motor's brushes (refer to Notes and Tips for Span testing an armature).



Span Test using the Motor's Brushes

Do Not Touch Test Leads when Test is in Progress!

The wave pattern produced in this test represents the voltage oscillation between the tester and the coils for the specific number of commutator bars spanned. For example, any 10 bars spanned in series on the armature should give the same pattern as any other 10 bars spanned. As the armature is rotated, all the commutator segments and therefore their respective coils, pass into the "test area" between the Hot surge test lead and the GRD lead.

NOTE: It is important that the same number of bars (and therefore coils) always be in the "test area". The test wave pattern for each span should match a reference wave pattern on the display for the complete armature if the coils are all good.

1. Remove all brush pig tail connections from the leads at the brush rigging for all sets of brushes to isolate the armature from the power source.

2. With the TLS switch in the LEADS GROUND position, connect test lead #1 to one of the brush assembly pigtails. Connect the GRD test lead to the shaft or other good ground on the frame.

NOTE: When testing armatures that have bars that are wired in series, it is very important to ground at least two bars of the armature a few bars away from those that are being surged. If this is not done, very high potential voltages to ground can develop in the armature due to a transformer effect in the coil.

3. Select the adjacent set of brushes or the brushes of the bar corresponding to the desired span. Connect test lead #2 and #3 to the pigtail of that brush assembly.

4. Select the TLS position #1. Be sure the Function switch is set to Surge.

5. Begin the test by pressing the test button or footswitch and slowly raising the Output control to the desired test voltage level. Carefully observe the wave pattern for its reference shape.

6. Store this wave pattern as the "reference" wave pattern for this span on this particular armature. Recall the reference wave pattern to the display (Use Quick Store if desired). Note the Peak Voltage displayed on the screen.

7. Begin testing again using the same Output voltage until the test wave pattern matches the reference wave pattern.

Do Not Touch Test Leads when Test is in Progress!

NOTE: The Zero Start Interlock is disabled only when the Funtion switch is set to AT101 for the AT101D accessory (See Supplement #: Model AT101D) and the Footswitch is depressed. Without the accessory and a footswitch, the Output must be turned back to zero or Min and then brought back up to the peak voltage value noted above in Step 6. The same test voltage must be used for each span tested.

8. Rotate the armature slowly through 360 degrees so that all commutator segments are tested while observing the reference wave pattern.

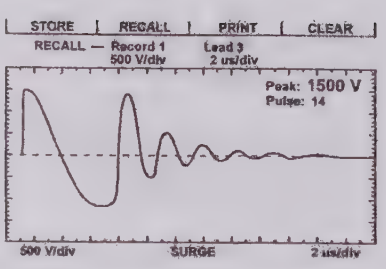
NOTE: It is recommended to release the Test button (or Footswitch) each time the armature is turned, but it is not necessary. Doing so minimizes the chance of marking the commutator.

If the test button or footswitch is not released each time the armature is turned, the wave pattern will show regular shifts and flickers as the brushes move across one commutator bar to the next. This wave pattern movements should be ignored as long as the trace returns to the reference wave pattern and remains stable when the brushes are again centered on top of the bars.

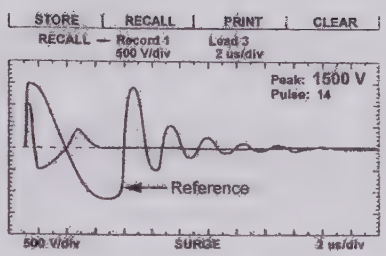
Determination of a Fault

If the insulation is weak or failing on a particular bar or coil of the armature, the test wave pattern will become unstable and Shift Left when the section that contains the fault passes through the "test area". The test wave pattern will no longer match the reference wave pattern. This indicates shorted windings within the span.

Usually, as soon as the bad bar is placed under the hot brush, the wave pattern will show the shift to the left as noted above. Thus the bar directly below the hot brush is the faulty bar. An example of a fault found surge testing using the motor's brushes is illustrated below.



Fault located under the ground brush Or outside of the surge test span



Fault grounded under the hot brush

Notes and Tips for Span Testing Armatures

- A test fixture can be used in place of using the motor's brushes to make contact with the armature.

  Set the span between the fixture's brushes to the desired number of commutator bars. Either the fixture can be moved around the commutator during testing, or the armature can be rotated. Procedures for testing and fault determination are the same.

- Always HiPot the armature to ground first. This gives an upper limit for the maximum voltage to apply when surge testing.

- The greater the span surge test voltage is, the more adequate the stress between bars is (ideally, 335 volts according to Pashen's Law). Voltage stress is measured by the differential or drop between each bar. For example, a 10 bar span with 1000 volts applied to it will result in a 100 volt stress between bars. If the span is lowered to 5 bars, 1000 volt applied to the span will result in 200 volts between bars.

  Consider, however, that a ten bar span at 335 volts between bars would require a span test voltage of 3350 volts. This potential to ground at the first coil may be too high. A lower span test voltage is recommended if, for instance, the HiPot test was only to 2200 volts.

- It is advantageous to keep the span as low as possible to still get a reasonably good ringing wave on the display. However, lowering the span reduces the resistance and inductance of the load under test. The

low inductive load may cause difficulty achieving the desired test voltage and a good ringing wave pattern on the screen.

- To simulate a fault, use an insulated screwdriver to temporarily short two commutator bars together that are in the "test area". This shows the response of the wave pattern when a fault exists. It gives an indication of what the user should expect to see.

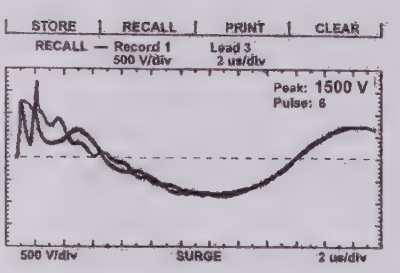
- Equalizer windings can separate the test wave pattern from the reference pattern seen during span tests. Thus, a good armature winding can appear to be bad. For example, a wave pattern for 7 bars spanned may sometimes match that for 11 bars spanned. In addition, the patterns may show a rhythmic shift consistently throughout the 360 degrees of rotation, (for instance, as the armature or fixture is rotated, every third bar shifts left a little), which is not a fault. This is due to the equalizers and does not indicate faulty windings.

- Releasing the Test button or the Footswitch before moving to the next bar during the test minimizes the chance of marking the commutator.

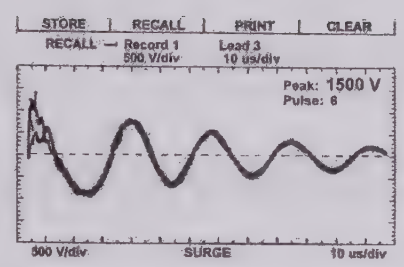
Testing Large AC Stators/Motors

Due to the physical non-symmetry of the input area, high capacitance, and inductance on some large AC high voltage machines, care must be exercised when evaluating the waveforms.

The screens below show wave pattern comparisons for a typical 4160V stator. The first wave pattern is produced when the Seconds/Div control (sweep rate) has been turned clockwise too far, expanding the display of the wave pattern. The sweep rate is set too fast. This wave pattern is actually the first half cycle of the full wave. Distortion is caused by the non-symmetrical, distributed capacitance in the input portion of the winding.



Seconds/Div set too far CW



Seconds/Div adjusted CCW

To correct for this display condition turn the Seconds/Div control counter-clockwise, slowing the sweep rate. The correct surge wave pattern will always extend below the zero line. Observe the natural ringing to the right of the point where the wave pattern crosses the zero line in a positive (upward) direction.

Good practice is to start with the Seconds/Div control turned to its counter-clockwise limit to begin when testing high voltage AC machines.

Notes and Tips for Large AC Stator/Motors

- Large AC motors with parallel windings may show little, if any separation of wave patterns when shorted or open windings are present. The inductance change caused by these faults is often not detectable. Instances have been noted where an end turn of a winding "has a hole blown in it," and yet surge wave pattern comparisons show no separation.

  As a result, it is critical to perform a winding resistance test with a milli-ohmmeter or micro-ohmmeter whenever evaluating the condition of a motor winding.

- The surge test must be done on each of the parallel windings individually for the highest degree of fault sensitivity.

Rotor Loading (Coupling) when Testing Assembled Motors

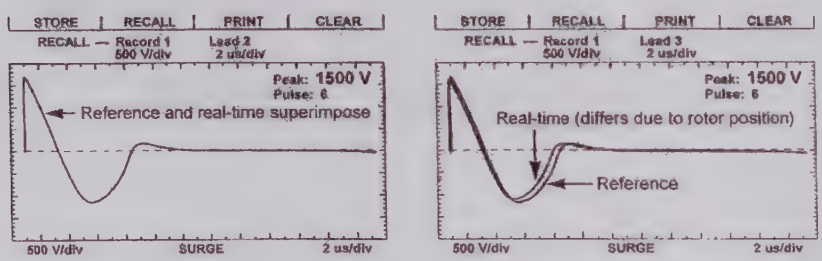
When testing assembled motors, the rotor can influence the shape of the surge wave pattern. These influences are as follows.

1. Loss of wave pattern amplitude: The inductive loading of the rotor causes rapid dampening (little to no cycles of the ringing pattern) of the wave pattern.

2. Separated wave pattern comparisons for good windings: Imbalance in the inductive coupling between the rotor and stator winding causes the wave patterns of two good phases to appear separated when they are compared. By turning the rotor, this coupling effect can be balanced out so the wave patterns superimpose.

Rotor loading can be understood when the rotor is considered as a secondary of a transformer. When one phase being surges has a different number of rotor bars under its stator windings than the other phase being surged and compared, there is a different transformer action existing for each phase. The wave patterns on the display indicate this difference by displaying separated wave patterns when they are compared.

Not all motors exhibit this characteristic. It is most prevalent in smaller, high efficiency motors with small tolerance air gaps. Separation of wave patterns that are due to rotor coupling can be determined when the wave patterns separate from the first positive peak downward, cross one another at the bottom (first most negative point) and separate again as they go upward (positive).



Wave pattern comparisons for motor with rotor in place.

The recommended procedure for testing assembled motors where rotor coupling may occur is as follows. Refer to Three Phase Motor Surge Test and Setup for

detailed instructions for surge testing and Storage and Print capabilities for discussions of the storage and recall functions.

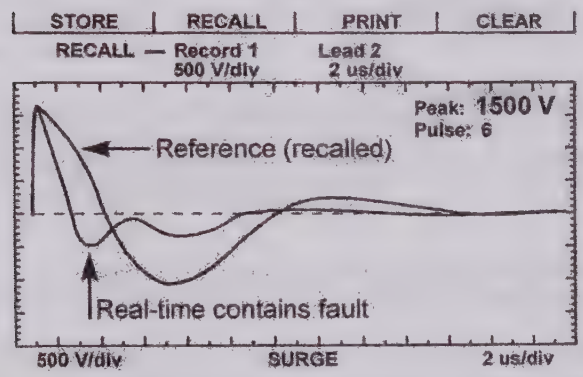
1. Surge test phase #1 of the motor. Store and recall the wave pattern by using the quick store function.

2. Surge test phase #2 of the motor. During the test carefully turn the rotor until the wave pattern superimposes that of phase #1 on the display. Store the results in Lead 2 in memory.

3. Repeat step for phase #3.

If the rotor cannot be turned, carefully observe the wave pattern as the test voltage is slowly raised. Watch for a sudden shift to the left, instability, or flickering which could indicate a winding fault. Many winding insulation failures will not be visible at low voltages but become apparent at a higher voltage.

NOTE: Rotor coupling does not impede the surge impulse from stressing the turn-to-turn or phase-to-phase insulation. It only causes the rapid damping of the wave pattern. This rapid damping decreases sensitivity in interpretation of solid faults. Unstable, flickering wave patterns clearly indicate a fault in assembled motors whether rotor coupling is present or not.



Motor with rotor in place and with faulty windings. One trace shift significantly to the left.

Testing Assembled Motors from the Switchgear

The Surge and HiPot tests are valid tests when testing from the switchgear at the motor control center. Not only are the windings of the motor tested, but the insulation on the connections and feeder cables phase-to-phase and phase-to-ground are tested.

Follow all the procedures for surge testing (also refer to Surge Testing). Keep in mind that different types and sizes of motors will give different traces, but the principle of testing assembled motors is still the same. When interpreting the wave patterns for good or bad windings, stability and symmetry are the most important factors.

WARNING!

The motor must be de-energized before testing!
Connect the test leads to only the load side of the open disconnect

Notes and Tips for Testing from the Switchgear

- The test motor should be properly tagged during the test as a safety precaution.
- All of the limitations and guidelines covered for testing assembled motors apply here (see Rotor Loading (Coupling) when Testing Assembled Motors).
- Any power factor capacitors in the circuit must be disconnected. If power factor capacitors are present, no waveform will be observed when the voltage is raised. This will also happen if the motor was not connected to the cable. Only a rise in the trace on the far left will be noted.

Do Not Touch Test Leads when Test is in Progress!

- The surge test circuit will be loaded by the feeder cable capacitance as well as the motor. Significantly higher Output settings will be needed to reach the required test voltage. If the surge tester is too small to handle both the cable and the motor load, a trace will be observed but the proper test voltage will not be reached. A higher output surge tester model will be required or the motor may have to be tested while disconnected from the feeder cable.

  There is no precise science to determine what size motor, with what size and length feeder cable a particular surge test model can adequately test. In general, the closer the size of the motor is to the recommended maximum motor size for a given model surge tester, the shorter the cables can be and still allow testing at the required voltage. Conversely, the smaller the motor size, the longer the cable can be.

Transformers

Transformers contain similar insulation systems as motors: ground, turn-to-turn and phase insulation. However, the spectrum of winding characteristics for transformers is much broader than for motors.

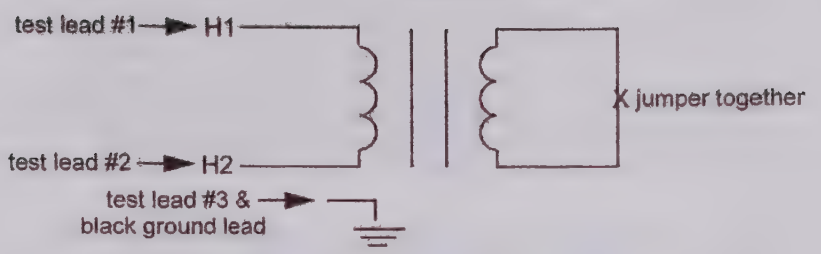
The Surge test is only one of many tests that should be performed to properly test a transformer. If the transformer has thousands of turns, the surge tester may not be sensitive enough to detect a single shorted winding. It may also sense the high inductance of a transformer as an open.

The following procedures for single phase and three phase transformers provide the basics necessary to surge test transformers. Please call Baker Instrument Company at 800-752-8272 for further assistance or if difficulties are encountered when testing transformers.

Single Phase Transformers

1. Jumper (or short out) the secondary side (low side) of the transformer.

2. Select TLS #1. Follow the diagram below to connect test lead #1 to H1 and to H2 of the transformer. The black GRD lead and test lead #3 go to the frame.



Single Phase Transformer Connections

3. Surge test the winding following the procedures outline for Single Phase Motors and Two Terminal Devices. The discussion of determining a fault applies.

NOTE: Secondary winding insulation problems are reflected into the primary winding, and will be observed on the display.

4. After completing the test, reverse the test leads (connect test lead #2 to H1 and test lead #1 to H2) and repeat the surge test. This is commonly referred to as "shooting in the other direction".

5. Repeat this test process for each TAP position.

Three Phase Transformers

It is beyond the scope of this manual to cover all possible transformer connections. It is important to remember that each line high side connection point must be surge tested to the other end of its own coil, and that the secondary side of the coil being surged must be shorted out (jumpered together and to ground).

NOTE: A wye-wye transformer with the star point internally tied can be surge tested without opening the tie point.

1. Use TLS position #1.

2. Connect the black ground test lead to the frame (ground) of the transformer.

3. Follow one of the charts below for connections for wye-wye or delta-wye transformers. The transformer windings should be surge tested for all the configurations shown.

4. Test procedures follow identically as for Single Phase transformer testing (refer to Single Phase Motors and Two Terminal Devices)

Determination of a Fault

The determination of a fault when surge testing a transformer winding follows that of the Two Terminal Device (refer to Single Phase Motors and Two Terminal Devices).

Wye-Wye Transformers

Test Lead #1	Test Lead #2	Jumper
H1	HO	XO to X1
H2	HO	XO to X2
H3	HO	XO to X3

Delta-Wye Transformers

Test Lead #1	Test Lead #2	Jumper
H1	H2	XO to X2
H1	H3	XO to X1
H2	H1	XO to X2
H2	H3	XO to X3
H3	H2	XO to X3
H3	H1	XO to X1

Do Not Touch Test Leads when Test is in Progress!

Do Not Touch Test Leads when Test is in Progress!

CHAPTER 9 DOCUMENTING TESTS

Inside.....

- Test Data Storage
- Recalling Test Data
- Printing Reports
- Compatible Printers

!

Do Not Touch Test Leads while test in Progress!

The Digital Tester comes equipped with a microcontroller based hardware that allows the user to digitize, store, recall and print test data for up to 10 motors or windings. This applies to Surge and DC Hipot testing. The data can also be uploaded to a computer using Baker Instrument Company's MTA for Windows software for further analysis.

There are ten Records available in memory. For each Record there are three Lead memory locations for recording three phase surge testing results. Each record can also record the results of Hipot tests.

The four FUNCTION KEYS above the display correspond to the four functions displayed beneath them. The main functions are STORE, RECALL, PRINT, and CLEAR and are listed across the top of the display. Subsequent submenus also correspond to the four function keys.

Store

Store is used to record measurements to internal memory on the testers.

Choosing Store reveals a list of memory locations available for surge and hipot tests. Ten available Record memory locations are then listed on the display.

Choosing STORE also reveals a submenu, with choices that correspond to the four function keys above the display.

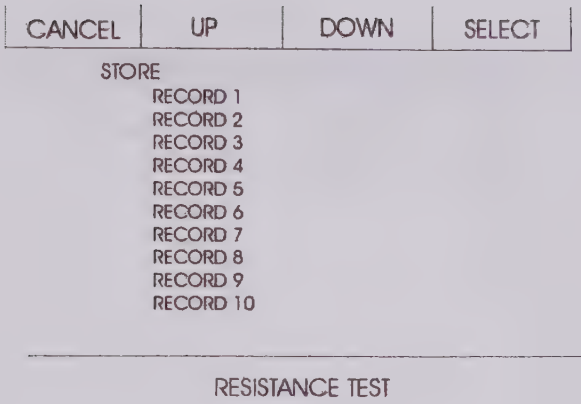
Do Not Touch Test Leads while test in Progress!

Store Record Submenu Options

QWK STR	UP	DOWN	SELECT
QWK STR represents QUICK STORE. The wave pattern or hipot/PI data that is currently on the display is automatically stored in memory of the selected record. The wave pattern will be stored in the Lead #1 location and will immediately display on the CRT. Operation will be returned to the main menu.	UP moves the cursor up the Record list.	DOWN moves the cursor down the Record list.	Press SELECT to choose the Record that the cursor is presently on. In Surge Mode: Press SELECT to reveal the next menu for Lead selection or to cancel a selection (see next page). In Hipot Mode: Press SELECT to store Hipot and/or PI data into the Record and return to the main menu.

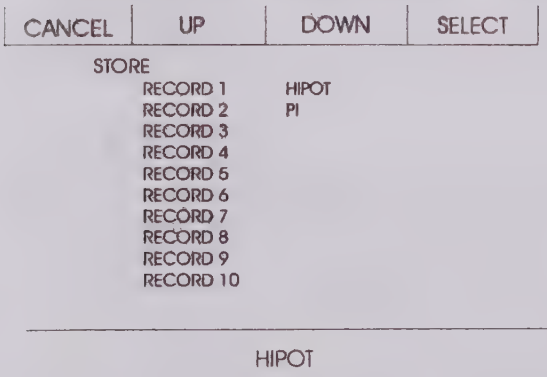
Store Resistance Data

If the tester is currently in the resistance test mode and store is selected, the display will allow the user to choose from 10 memory locations that are listed on the display.



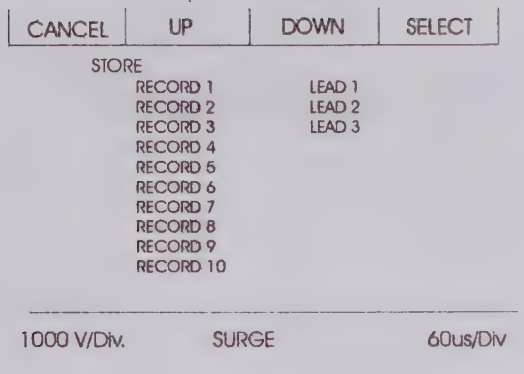
Store Hipot and PI Data

If the tester is currently in the Hipot mode, the next display will allow the user to choose whether to store Hipot or Polarization Index data into memory.



Store Surge Data

If the tester is currently in the Surge mode, the display will allow the user to choose the Lead location in memory for Surge tests. Three Lead locations are available for each Record.



STORE Lead Submenu Options

CANCEL	UP	DOWN	SELECT
Press CANCEL to return to the main menu without storing any data.	UP moves the cursor up the Lead list.	DOWN moves the cursor down the Lead list.	Press SELECT to choose the Lead of Hipot data type that the cursor is on. Data will be loaded into memory. The user will be returned to the main menu.

Recall

RECALL is used to retrieve measurements from internal memory to the display.

Choosing RECALL reveals a list of memory locations available for resistance, hipot and surge tests. Ten available Record memory locations are then listed on the display.

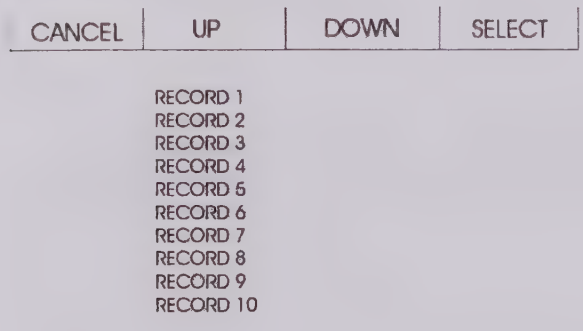
Choosing RECALL also reveals a submenu, with choices that correspond to the four function keys above the display.

Recall Record Submenu Options

SUMMARY	UP	DOWN	SELECT
Press SUMMARY to display the Resistance data, Surge data in all three leads, the Hipot, and the PI data stored in the Record the cursor is presently on. Resistance, all three surge wave patterns, Hipot, and PI results will be displayed simultaneously and operation will be returned to the main menu.	Up moves the cursor up the Record list.	Down moves the cursor down the Record list.	Press SELECT to choose the Record that the cursor is presently on. In Surge Mode: Press SELECT to reveal the next menu for lead selection or to cancel a selection (see next page). In Hipot Mode: Press SELECT to recall Hipot and/or PI data from the Record and return to the main menu.

Recall Resistance Data

If the tester is currently in Resistance mode, the tester will display the recorded Resistance data for the selected record.



Do Not Touch Test Leads while test in Progress!

Recall HiPot Data

If the tester is currently in Hipot mode, the tester will display the recorded Hipot and Polarization Index data for the selected Record.

SUMMARY	UP	DOWN	SELECT

RECORD 1
RECORD 2
RECORD 3
RECORD 4
RECORD 5
RECORD 6
RECORD 7
RECORD 8
RECORD 9
RECORD 10

HIPOT
PI

1000 V/Div. HIPOT 60us/Div

Recall Surge Data

If the tester is currently in Surge mode, the next display allows the user to choose the Lead location from which to recall a wave pattern. Three Lead locations are available for each Record.

SUMMARY	UP	DOWN	SELECT

RECORD 1
RECORD 2
RECORD 3
RECORD 4
RECORD 5
RECORD 6
RECORD 7
RECORD 8
RECORD 9
RECORD 10

LEAD 1
LEAD 2
LEAD 3

1000 V/Div. SURGE 60us/Div

Do Not Touch Test Leads while test in Progress!

Recall Lead Submenu Options

CANCEL	UP	DOWN	SELECT
Press CANCEL to return to the main menu without recalling any data. Press ERASE to delete the record	UP moves the cursor up the Lead list.	DOW moves the cursor down the Lead list.	Press SELECT to choose the Lead that the cursor is presently on. Surge data is recalled from memory to the display and the user is returned to the main menu.

Note: RECALL displays only one wave pattern from memory and clears any wave pattern that has been previously recalled to the screen. See Three Phase Motor Surge Test and Set-up, step 9 for procedures to compare two surge wave patterns simultaneously.

Print

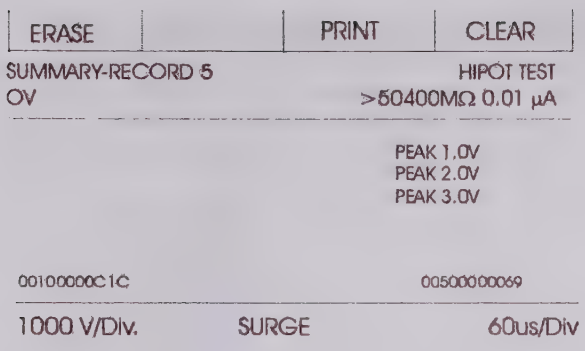
Print will print the record currently on the display.

Clear

Clear will remove or blank out the wave pattern and message area of the display. It has no affect on memory locations or the data stored there.

Erase

The whole record erase feature allows the user to erase all of the Resistance Hipot, PI and Surge data of a particular record after that record's data has been recalled with the Recall Summary feature.



Compatible Printer Information

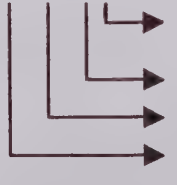
The HP printer support includes those HP printers that use the Hewlett-Packard PCL 3 printer language/command set. A non-inclusive list of compatible printers follows:

- 500C
- 550C
- 600C
- 610C
- 612C
- 695C
- 697C
- 832C
- 895C
- 970C

The 895C and 970C are unique in that they have universal input power supplies and will work worldwide, regardless of available line power voltage. Any printers purchased for export should be purchased as an export printer which will include HP's international warranty.

Firmware that will operate Hewlett Packard printers have an "HP" in the version number.

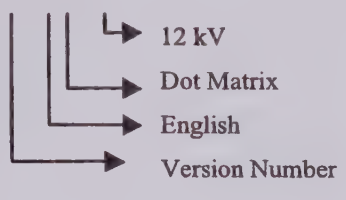
Example: 1.39EHP12



Do Not Touch Test Leads while test in Progress!

Epson dot matrix and Epson Inkjet printers may also be used. These firmware versions will have a D or 6 in the version string.

Example: 1.39ED12



Dot matrix printers that respond to the Epson Esc/P command set may also be used. Some Panasonic, Canon and Olivetti printers are known to work.

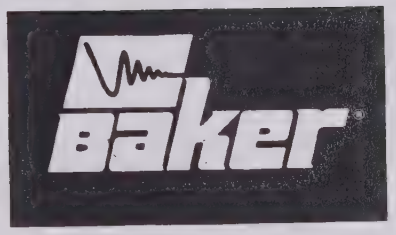
Do Not Touch Test Leads while test in Progress!

Do Not Touch Test Leads while test in Progress!

APPENDIX A: TYPICAL WINDING FAULTS

Inside....

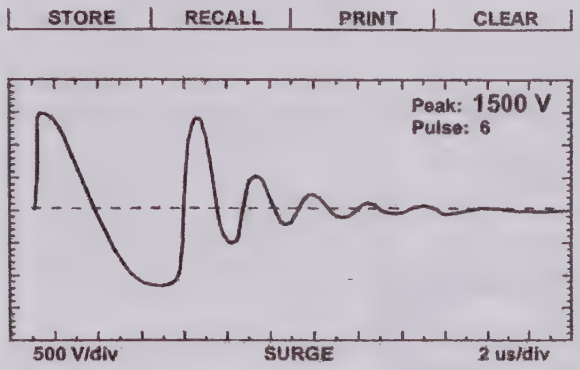
- Typical Winding Faults



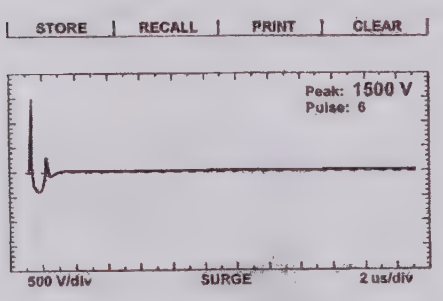
Do Not Touch Test Leads while test is in progress!

For initial determination of winding faults, refer to the following figures. These wave patterns are typically seen for three phase, wye-connected, lap-wound induction stators. They provide a reference for associating a characteristic wave pattern with a fault type.

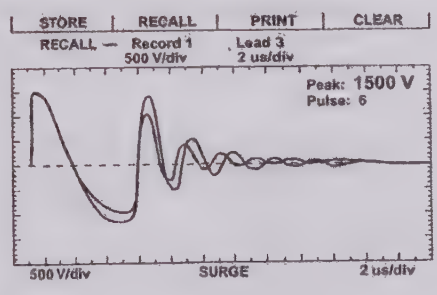
Note: Variation from these wave patterns is to be expected. Do not consider these wave patterns as absolute. Remember, that due to the variety of motor windings and connections that exist, each motor winding will have its own signature wave pattern. Memorization or exact matches to the following patterns is not necessary when testing.



Good coil

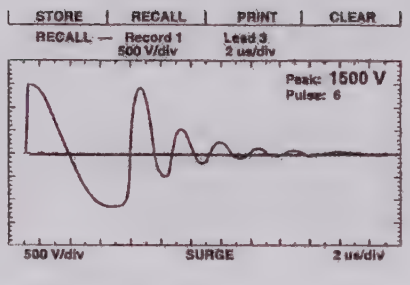


Shorted single winding

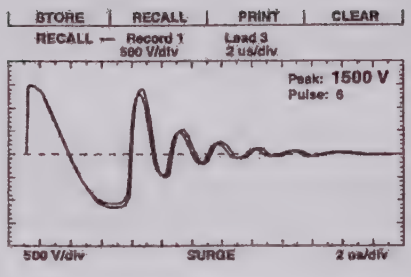


Short partial ground

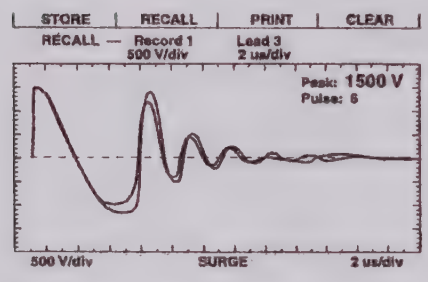
Do Not Touch Test Leads while test is in progress!



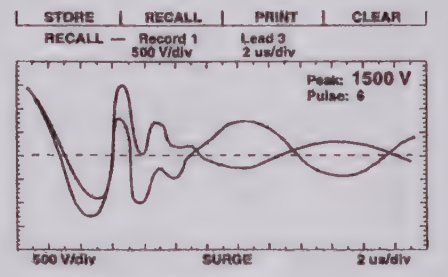
Solid ground coil



Solid turn-to-turn short

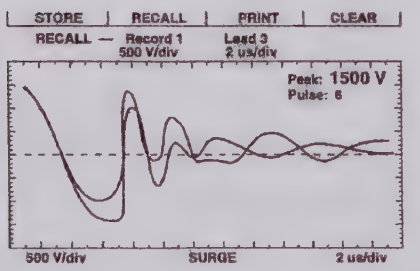


Coil-to-coil short

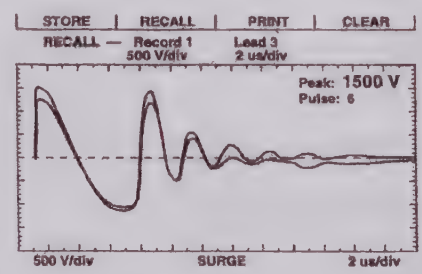


Phase-to-phase short

Note: If all three wave pattern wave comparisons surge testing show considerable separation when testing three phase windings, the motor has a Phase-to-Phase short. Because two phases are faulty, a good wave pattern will not be achieved in any position of the TLS.



Group-to-group short



Reversed coil

Do Not Touch Test Leads while test is in progress!

APPENDIX B: TROUBLESHOOTING

Inside...

- Self help & Diagnosis
- Common Application Problems
- Service: What to do first
- Warranty Return
- Warranty Return Form

Do Not Touch Test Leads while test is in Progress!

Please review this section before you call Baker Instrument Company or return the unit.

Self Help and Diagnostics

Problems in testing often crop up. If you are experiencing a problem and believe the problem might be with the Baker Instrument Company Digital Tester, please take the following steps before calling or returning the unit.

By performing these procedures and having the requested information available, Baker Instrument Company's Service or Applications Departments will be able to better analyze your situation and provide the appropriate response. Either department may be reached toll-free at 800-752-8272 or 970-282-1200 for assistance.

Step #1: Basic Information

Take down all basic instrument information, including the following:

Model #
Serial #
Product #

Note: All information above is located on the rear panel product label. If the tester has special options installed that you are aware of, please note these. Any and all information you know or can derive would be of help! A great tool would be a printout or sketch of the waveforms displayed on the tester.

Step #2: Applications or Service Problem?

Generally, if a problem is noted *Only* when testing a specific motor/generator or other coil type, then Applications would be involved. See **Applications: What to do First!** Please call Baker Instrument Company, Sales Department for Applications assistance.

If you can *Not* say the problem is associated with any *One* type of motor/generator, or other coil type, then Service would be involved. See **Service: What to do First!**

Applications: What to do First!

Review the section below on Common Application Problems. Please have Basic Information about your tester and specific information about the motor you are testing available when calling or faxing to assist Baker Instrument Company personnel in determining a solution to your problem.

Examples:
- Hp rating
- kW rating
- RPM rating
- Operating voltage & current
- How the item being tested is wound and/or number and type of coils
- Application of motor/generator

In short, any and all information you know or can derive from the motor nameplate would be of help. A great tool is a printout or sketch of the waveforms displayed on the tester. If you have a FAX available, send a draft to 970-282-1010, attn: Applications.

Common Application Problems

Following are the common application-related problems. Please review the following cases.

1. The surge tester will not give the desired output test voltage or the apparatus under test.

The Test motor may be too large for the instrument being used. The impedance of the windings may be too low.

The Digital tester may be at fault in this case. DO NOT continue testing until you contact Baker Instrument Company Applications Department.

2. Separation of compared wave patterns is seen when surge testing on coils that are assumed to be good, even on brand new motors or windings. Often, separation is seen in all three comparisons for three phase motors, but to varying degrees. There may not be separation throughout the whole wave pattern.

This situation can be seen in DC fields or rotating poles. Be sure the coils being compared are being tested in identical configurations; i.e. both coils are wound clockwise beginning to end.

On very large equipment, slight differences in capacitance to ground may be the cause. At low voltage levels, begin the test again with the black GRD lead removed from the motor frame. If the separation is now gone, capacitance to ground was effecting the test.

3. There is no dampened sinusoidal wave pattern on the display when testing a coil. The wave pattern rises on the left and then slowly drops as it trails off to the right of the screen. It may or may not cross the zero/base line.

The coil under test is probably too high of an impedance to get a good working pattern. The coil may be very high in resistance and turn counts. The inability to surge test this coil, or group of coils in series, will remain unless they can be broken down to smaller units of lower impedance.

A broken test lead may be the cause. Under heavy use, test leads should be checked weekly to ensure that there is no breakage. Grasp the boot and clip in one hand while pulling on the lead with the other hand. A broken lead will stretch, whereas a good lead will not.

4. The instrument has the "Open Ground" light lit.

The instrument has an earth ground safety detect circuit. In certain situations, such as about ship, the detector may think there is no safety ground present. The detector can be disabled internally by removing the jumper wire present at J8-motherboard connector. To remove the jumper, remove the I/O, A/D and Controller boards from the center front panel of the tester. Look inside the card cage for the J8 jumper, clip it out with a small diagonal cuter, replace the cards in the order taken out.

5. How to test using the Baker Instrument with a generator to supply AC power at a remote site.

The instrument will require a driven or earth ground to operate at a remote site, and will need to have the safety ground detector disabled (#4 above).

6. Test lead clips need replacement.

Slide the rubber test lead boots back, remove the old clip and replace the clips with the new ones.

Do Not Touch Test Leads while test is in Progress!

7. How and why to test from the motor's star point.

When testing very large, high capacity motors, it may be impossible to reach the desired test voltage. Delta wound machines usually have an externally connected star point. It is often possible to apply 25-50% more voltage to a single phase of a winding, if it is disconnected at the star point, and tested end to end. The downside is the fact that the connection needs to be broken, and re-taped after the test, which can take several hours. The upside is a smaller, lighter, less expensive tester can be performed on a larger selection of equipment.

8. Cleaning a dirty display.

Use a standard household cleaner such as Windex with a soft clean cloth, since the screen is plastic. Steel wool or sandpaper will destroy the monitor screen.

9. Doing high voltage testing with a printer attached to the printer port.

The surge pattern seen may show distortion from the interference. Additionally, it is possible to damage the printer port with the PP30D 30kV power pack. Quite high levels of RFI/EMI may be generated when the PP30D is doing a surge test. Print the results after testing is done, it will prolong the service life of the Baker Instrument and any peripheral devices such as printers or laptop personal computers.

10. Why the printer port is not specified for operation with cables longer than 10 meters.

The printer port on the D6/12R is a IEEE 1284 compliant parallel port. Electrical standards for parallel ports do not specify correct operation with cable lengths over 10 meters. Data can become scrambled and cause printer or computer problems. Baker Instrument Company suggests the use of a 2 meter cable.

11. How to check/replace blown power entry module fuses.

The power entry module of the D6/12R contains 2 fuses, one for AC Line and one for AC Neutral. If the unit does not appear to have a display, the first thing to check is the fuses. The fuse block is easily removed with a pair of needle nose pliers. Baker specifies the following fuse rating: 5x20mm 250V 2.5A Slow-Blow.

12. The screen shows a wavy appearance when the unit is at or near maximum output surge test voltage.

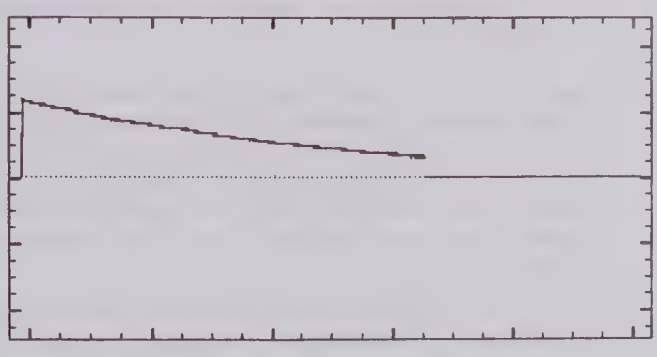
The AC power source needs to supply at least 200 watts with minimal sag. If the AC supply is extremely weak, the CRT may show some wavy appearing lines. Use a power supply rated at least to 500 watts for reliable, trouble-free performance.

Service: What to do First?

Because history has shown that several simple solutions which do not require return of an unit may arise, please perform the following checks.

Open Condition Display

Note the figures below. Is the surge waveform like this?



If yes, the unit may have at least one broken test lead causing an Open condition. In most cases, the test lead in common with the two TLS positions that produces these types of wave patterns is the lead which is broken.

Verify this by pulling on the book/clip assembly of the lead. A broken test lead will stretch. If it does not repeat this procedure at one foot intervals for the length of the lead. If the leads of the tester are good, check the connections and continuity of the test winding.

Hipot Display Checks

The Hipot display shows only the VOLTAGE or CURRENT bar. One of three problems might exist.

- The item being tested is in fact faulty and has either low insulation resistance or open connections.
- The tester has an internal problem.
- The tester has a test lead problem as shown above for an Open Condition.

Disconnect the test leads from the motor and isolate the tester from any grounded surface. Reduce the Output to minimum and attempt a Hipot test with an open lead condition. Your display should indicate a rising voltage bar. The current bar may rise slightly but fall back to zero when the output increase is stopped.

Note: It is not necessary to run the output control at a high level to determine if the analyzer is working properly.

If the display still shows **NO** voltage bar call Baker Instrument Company Service Department. Use a meter to confirm the insulation resistance of the device being tested.

Current bar operation can be tested by shorting test lead #1 and the ground lead together. Under this condition, the voltage bar will NOT move off the zero line and the current bar should rise **very rapidly** and activate the Hipot Overcurrent Trip warning light (**Hipot Trip**). If the Hipot Trip light does *not* light, check for open test leads at either test lead #1 or the ground lead (see **Open Condition Check**). If the problem persists, contact Baker Instrument Company Service Department.

Hipot Over Current Trip Check

The Hipot Trip lamp either does not activate (under known shorted conditions) or it will not go out when test is discontinued.

Call the Service Department immediately for assistance. Please record information off the unit and the specific problem prior to calling.

Open Ground Check

The Open Ground warning prevents testing.

Answer these questions:

1. Have you recently moved the unit to a new location with possibly an ungrounded outlet?

2. Is the unit being operated in a field where the AC power source is unknown?

3. Is the unit being operated on a scope cart that has its own outlet or power source?
4. Is the unit being operated using a two-wire extension cord?

5. Is the unit being operated on a transformer isolated circuit?

If you answer is yes to any of these questions, the unit is probably operational and indicating you have an open AC line ground connection.

In the case of numbers 1 through 3 above, use an outlet tester to assure proper wiring connections to the outlet. For number 4, replace the two-wire extension cord with a two-wire/with ground extension cord. For number 5, or any of the conditions noted above, use a grounding strap to a good earth ground.

In the case of number 5, call Baker Instrument Company Service for assistance. There is an override available but precautions should be taken.

Limited Output Surge Waveform

The display shows a limited output (amplitude) surge waveform. The display rises normally but stops at some point. Alternatively, you must continually increase the output control for successive tests to achieve the same output test amplitude.

Call the Service Department immediately for assistance on this or any other abnormal condition noted. Please record basic information from the tester and the specific problem prior to calling.

Precautions for Proper Operation

- **Never raise the output control to attain a display from a blank screen!**

Do Not Touch Test Leads while test is in Progress!

- **Never attempt "simulated" problems by disconnecting the leads and positioning them to arc against each other!**
- **Never come in contact with the item being tested and the test leads or with the tester and the item being tested!**
- **Never attempt a two-party operation. Always know what test is being performed and WHEN!**
-
- **Never attempt a "Burn-Out" of a detected fault with the tester!**

Warranty Return

Please review the Warranty Notes and Shipment sections at the beginning of this manual before sending your tester to Baker Instrument Company for Warranty repair.

The Warranty Return Form on the following page MUST BE FILLED OUT and RETURNED with the tester to obtain warranty service. This form will help to ensure that Baker Instrument Company will identify the problem, quickly repair our unit, and return it to you.

Warranty Return Form

Please fill out all the following information and return this form with your tester. Make a copy for your records before sending this to Baker Instrument Company.

Note: Be sure to follow the guidelines for shipping when sending your tester to Baker Instrument Company.

Company Name: _____

Your Name: _____

Mailing Address: _____

Shipping Address: _____

Phone Number: _____ Fax: _____

From the Name Plate on the back of the Tester:

Baker Product Number: _____

Model Number: _____

Serial Number: _____

Description of the Problem:
Please give as much information as possible (what is not working, when it happened, what was being tested, any unusual noises, etc.) even if you already talked to someone at Baker Instrument Company by phone. Use the back of this form if necessary.

Person Contacted at Baker: _____

Ship the Tester to: Baker Instrument Company, 4812 McMurry Avenue, Fort Collins, CO 80525, Attn: Service Manager.

Do Not Touch Test Leads while test is in Progress!

Appendix C: Technical Specifications and Calibration Procedure

Inside.....

- D12R/D6R Technical Specifications

Do Not Touch Test Leads while test is in Progress!

Do Not Touch Test Leads While Testing is in Progress!

Technical Specifications

	Model D3R	Model D6R	Model D12R
Surge Test			
Output Voltage	0-3000 Volts	0-6000 Volts	0-12000 Volts
Max Output Current	190 amps	350 amps	400 amps
Pulse Energy	0.18 joules	0.72 joules	2.88 joules
Sweep Range	2-2000μ seconds	2-2000 μ seconds	2-2000 μ seconds
Volts/Division	250/500/1000/1500	250/500/1000/ 1500	500/1000/2000/ 3000
Repetition Rate	5 Hz	5 Hz	5 Hz
Voltage Measurement & Accuracy	+/- 12%	+/- 12%	+/- 12%
DC High Potential (Hipot) Test			
Output Voltage	0-3000 Volts	0-6000 Volts	0-12000 Volts
Max Output Current	1000μ amps	1000 μ amps	1000 μ amps
Current Resolution	0.1/1/10/100 μ amps division	0.1/1/10/100 μ amps division	0.1/1/10/100 μ amps division
Over-Current Trip Settings	1/10/100/1000 μ amps	1/10/100/1000 μ amps	1/10/100/1000 μ amps
Full Scale Voltage & Current Measurement & Accuracy	+/- 5%	+/- 5%	+/- 5%
Meg-ohm Accuracy	+/- 10%	+/- 10%	+/- 10%
Max Meg-ohm reading	50,400 MO	50,400 MΩ	50,400 MΩ
Physical Characteristics			
Weight	40 lbs	40 lbs	40 lbs
Dimensions	19 x 8 x 23 in.	19 x 8 x 23 in.	19 x 8 x 23 in.

Do Not Touch Test Leads While Testing is in Progress!

Power Requirements	85-264 VAC 50/60 Hz	85-264 VAC 50/60 Hz	85-264 VAC 50/60 Hz
Resistance Measurement Display	.0008 ohms – 216 ohms	.0008 ohms – 216 ohms	.0008 ohms – 216 ohms

Accuracy of Measurements - Coil Resistance Test

Approximate Range Resistance	Resolution	Full Scale Accuracy
140Ω - 20Ω	1Ω	+/- 5%
20Ω - 2Ω	100mΩ	+/- 5%
2Ω - .2Ω	2 mΩ	+/- 5%
.2Ω - .020Ω	2 mΩ	+/- 5%
.020 - .0008Ω	1 mΩ	+/- 5%

Testing Accuracy - Hipot Measurements

Range	Approximate Maximum Measurable Current	Resolution	Full Scale Accuracy
100µA/Div Range	900µA +/- 5% or 45 µA	+/-5% from 90µA-900µA	+/-5%
10µA/Div Range	90µA +/- 4.5 µA	+/-5% from 9µA - 90µA	+/-5%
1µA/Div Range	9µA +/-.45µA	+/-5% from .9µA - 9µA	+/-5%
0.1µA/Div Range	.9µA+/-.045µA	+/-5% from .1µA - .9µA	+/-10%

Voltage Measurement Accuracy – Surge (D12R)

Range	Resolution
500V/Div	+/- 12% from 500V – 1960 V
1000V/Div	+/- 12% from 500V – 3930 V
2000V/Div	+/- 12% from 1000V – 7870 V
3000V/Div	+/- 12% from 2000V – 11900 V

Do Not Touch Test Leads While Testing is in Progress!

Voltage Measurement Accuracy – Surge (D6R/D3R)

Range	Resolution
250V/Div	+/- 12% from 250V – 980 V
500V/Div	+/- 12% from 500V – 1960 V
1000V/Div	+/- 12% from 1000V – 3930 V
1500V/Div	+/- 12% from 1500V – 5950V

Do Not Touch Test Leads While Testing is in Progress!

NOTE: Please contact Baker Instrument Company prior to calibration to ensure that the enclosed calibration procedure is the most current.

Baker Instrument Company 4812 McMurry Ave Fort Collins, CO 80525	**Doc. Title:** Quality Control/Calibration Procedure D3R/D6R/D12R	
	Doc No: 76-006-003	Rev. No.: B
	Date: 8/15/02	Pages:

MODEL:_____(Include language type)
Serial #: _____
Firmware version: _____
30KV serial #: _____(If present, record type/serial number)
Technician: _____

Required equipment:

Fluke 77 or equivalent digital multi-meter with valid calibration certification.
Serial #_____
Fluke 80K-40 or equivalent high voltage probe with valid calibration certification.
Serial #_____
Potentiometer adjustment screwdriver.
Caddock MG810 or EBG SGP103 or equivalent 10 Megohm 15 Watt 1% High Voltage resistor .
Caddock MG810 or EBG SGP103 or equivalent 100 Megohm 15 Watt 1% High Voltage resistor.
Caddock MG810 or EBG SGP103 or equivalent 1000 Megohm 15 Watt 1% High Voltage resistor.
Assorted resistance values in decade steps from .02 Ohm to 200 Ohm, with actual values verified within 1% by use of a calibrated micro-ohmmeter.
TEKTRONIX TDS 320 100Mhz or equivalent digital storage oscilloscope with valid calibration certification. Serial # _____
TEKTRONIX P6015A 1000X oscilloscope probe or equivalent with valid calibration certification Serial # _____

Typical technician workbench tools i.e. Philips screwdriver, needlenose pliers etc…

Do Not Touch Test Leads While Testing is in Progress!

Recommended additional equipment:

Baker Instrument 80-111 digital series extender card.
2 Fluke, or Mini-grabber type test leads for Fluke digital multi-meter 24 inch length.
Baker Instrument digital series 2 manual
Baker Instrument schematics: 70-D212-001 and 002, 80-D200-001 thru 80-D200-008
10 Caddock MG810 or EBG SGP103 or equivalent 1000 Megohm 15 watt 1% resistors, in series, on 1.5" tall insulating standoffs, on a lexan or plexi-glass plate.

1 to 5 milli-henry coil of wire. Actual value is not critical unless it is below 40 micro-henry

Check and record the following:

1) Check **ALL** hardware for tightness, including the following: Test lead clips, resistance strain relief fitting, P.C.B mounting hardware, main chassis hardware, CRT tube mounting hardware

Initial: _____

2) Visually check and inspect the wire harness for any broken or pinched wires, making sure no wires are crushed under power supplies, sheet-metal etc…Look at the wires coming from the power entry module. The black and white wires should be tightly twisted together, to minimize field effect on the CRT display. If the CRT appears "wavy" the wires are probably not twisted 2 turns per inch

Initial:_____

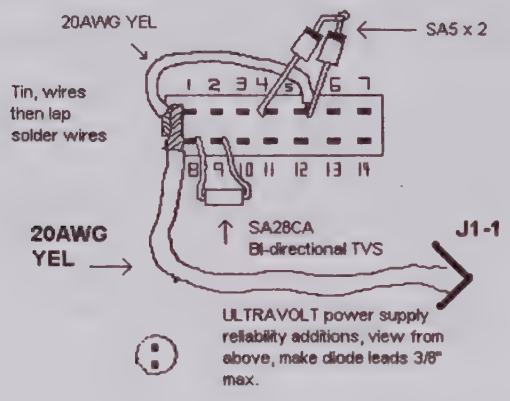
3) Tug gently on the wires coming from the P.C.B with a pair of needle nose pliers, to test for poor crimps and electrical connections

Check the jumpers on the 80-D200-007 power board to make sure that W2 is installed

Initial:_____

Do Not Touch Test Leads While Testing is in Progress!

Check the appearance of the surge suppressor diodes soldered across the power



supply pins as shown in the drawing above: Note: Yellow wires may be present=OK

Circuit board check/inspection.

The responsible technician shall have at his disposal the following circuit boards ready for installation into the D3R/D6R/D12R circuit board card cage. The technician shall perform these tasks following ESD precautions, with an anti-static wrist strap on the wrist, and an anti-static work mat present and grounded at the workbench.

80-D200-001Controller board
80-D200-003 I/O board
80-D200-006 A/D board

Visual Inspection:

Inspect each of the above assemblies for the following, correct as needed.

Solder bridges, cold solder joints.
I.C. chips loose, backwards or incorrectly installed in the sockets.

Dirty or contaminated P.C.B surface.
Bent or contaminated pins at 96 pin card edge connector.
Backwards polarized components such as diodes, capacitors or transistors.

4) Inspect and note the revision level of the following assemblies:

	REV:	QC ok?
80-129-002/003		
80-D200-001:		
80-D200-002:		
80-D200-003:		
80-D200-004:		
80-D200-005:		
80-D200-006:		
80-D200-007:		
80-D200-008:		

APPLY AC 115/230 V to power entry module:
Fuses present at power entry?

5) Apply AC power(single phase) to the power entry module, with fuses installed. 115VAC(+/- 5%). Measure with Fluke DMM or equivalent, the following DC voltages:

+ 5 VDC, acceptable range 4.95-5.10 VDC, at card cage power supply, record; _____ VDC
This is supposed to be a BROWN wire. High Line; _____ VDC

+15 VDC, acceptable range 14.0-16.0 VDC, at card cage power supply, record; _____ VDC
This is supposed to be a RED wire. High line; _____ VDC

-15 VDC, acceptable range –14.0 –16.0 VDC, at card cage power supply, record; _____ VDC
This should be a BLUE wire. High line; _____VDC

Do Not Touch Test Leads While Testing is in Progress!

+12VDC, acceptable range 11.9-12.1 VDC measure at resistance power supply: _____VDC
This is supposed to be a RED/WHITE wire. High line; _____VDC

+24 VDC, acceptable range 23.0-25.0 VDC measure at +24 power supply _____VDC
This should be a PURPLE/YELLOW wire. High line: _____VDC

HIGH LINE TEST

Verify all of the above voltages with 230VAC applied to the power entry module, record result's above.

DISPLAY ADJUSTMENTS

Upon satisfactory visual inspection the 80-D200-001 board is ready to have the EPROM installed.

Program the correct version and language of EPROM for the type of unit being produced.
Use the production computer program to select and program the EPROM. Being sure to install the EPROM in the IC socket in the correct polarity.

Then the technician shall place the 80-D200-001 board into the center slot of the D3R/D6R/D12R card cage, and apply power to the power entry module. The Baker Instrument should now enable the CRT monitor, with "BAKER" seen on the CRT display.
Note: The display may be dim, blank or excessively bright, this is usually the CRT controls and adjustments, they will only be adjusted when the 80-D200-006 A/D board is installed. Turn the unit off.

1. Inspect the A/D board. Install the A/D board (the left-most PCB in the card cage) (80-D200-006) and turn the unit on. At this point the unit should pass all of the self-tests. If any of the self tests read "FAILED", troubleshoot the unit before proceeding.

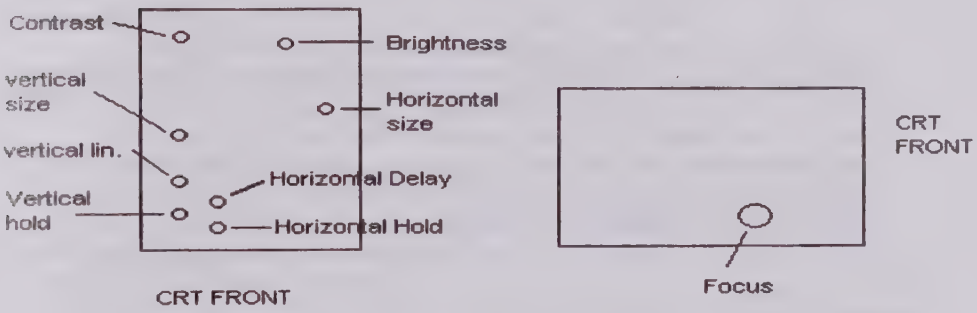
2. Inspect the I/O board (80-D200-003). Turn off the unit and install the I/O board (the right set of card guides).

3. Turn the unit on, again check the +15V, -15V, and +5V lines on the power supply. If the voltages are not within acceptable range, adjust the pot on the power supply until the voltage is achieved.

4. Adjust the CRT pots as shown. The CRT should be adjusted to give the sharpest graphics and most well centered picture. Extreme care should be used when adjusting the CRT since high voltage is present. The technician is required to make sure the CRT is not pressing on the blue plastic CRT screen, while looking at the display, press firmly on the center of the screen, the screen will depress slightly. If the screen depresses less than 1/4" before contacting the glass of the CRT, the CRT shall be moved back.

   pass/fail? Initial:_____

5. To avoid problems with the CRT when the unit heats up, a CRT adjustment is necessary. Start by grounding pin 6 on the CRT. The screen will start spinning until horizontal hold is adjusted correctly. After the screen



   stabilizes, remove the ground connection. Readjust the image using horizontal delay, if needed.

NOTE: Adjust horizontal size with metric M3 wrench. The potentiometer is ceramic and is **VERY** fragile.

1/O Card Test/OPEN GROUND

6. Plug the unit into the open ground connector and power unit on. To test the open ground circuit. Do not touch the unit chassis or front panel while testing this circuit to avoid grounding the tester through your body. The leads energized lamp should not turn on during this test. Do both surge and HIPOT. Press in the "TEST" button several times. The H.V. circuitry must

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NOT energize in this condition. NOTE: The ESD mat may allow a ground path, so disconnect it at the wrist strap for this test.
If successful, power off the unit and plug in with grounded plug.
Initial: _____

7. Install a footswitch into the "FOOTSWITCH" receptacle. Press it. The leads energized light should come on and the Baker Instrument should initiate a test. Initial:_____

8. Turn the "TEST SELECT" switch to lead 1 and the test "FUNCTION" switch to surge. Hook up the 5mH load to leads 1 and ground.

9. Check the I/O board for the correct switch stops so that the ranges for V/Div and μa/Div are correctly displayed. Surge V/Div 500, 1000, 2000, and 3000. Hipot μA/Div = .1, 1, 10, 100. Hipot v/div=500, 1000, 2000, 3000.

10. Check the operation of the soft keys by storing, recalling, clearing and printing several waveforms. Be sure that you can save to every record. Also verify that an error message comes up with no printer connected. Hold the clear button in for several seconds to check that the revision of the software is the latest version. Be sure to print a waveform and keep it with the unit Calibration Certification. Stamp it: trial printout. Do a recall summary on all 10-memory locations.

	Surge:	HIPOT:	Resistance:
Record 1			
Record 2			
Record 3			
Record 4			
Record 5			
Record 6			
Record 7			
Record 8			
Record 9			
Record 10			

Error message with no printer connected? Initial:_____
Software/Firmware correct? Initial:_____

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Printer, correct printout size, does not take several tries to get it to work, no double spacing?

Initial:_____

17) Connect the Baker Instrument printer port to the parallel port of a IEEE1284 compliant parallel port equipped computer with the MTA for Windows application present and running.
Consult the MTA for Windows user manual for principles of operation.

From the motor tree view select the HIPOT test, run a HIPOT test, making sure the Baker Instrument transfers and displays data correctly on the computer monitor. Initial:_____

From the motor tree view, select the SURGE test, run the SURGE test, making sure the Baker Instrument transfers and displays data correctly on the computer monitor. Initial:_____

Calibration procedure DC HIPOT Voltage, Current

This procedure is to be followed for the DC HIPOT function of series 2 D6R and D12R tester

An adequate insulating test surface is required. A metal or wooden workbench may be too conductive to give satisfactory results. At all times the high voltage test leads shall be clean and free of surface contaminants. At all times the high voltage test leads shall be electrically isolated from the floor, or other potentially conductive surfaces or personnel.

The high voltage test leads may have to be elevated away from conductive surfaces, to eliminate leakage effects due to bulk resistance of the high voltage silicone rubber test lead material.

The procedure shall be performed when ambient temperature, and the test equipment temperature, is above dew-point, if the procedure is performed at temperatures below dew-point, surface condensation may occur and electrical surface leakage may be excessive, possibly leading to mis-calibration.

If the Baker Instrument unit has the case top installed, and if following steps indicate the need for re-calibration, remove the 24 screws that hold the top of the enclosure. Remove the enclosure top by lifting it upwards. This will allow technician access to the calibration trimmer potentiometers on the 80-D200-003 I/O board, or 80-D200-006 A/D board. If the technician has the Baker

Instrument 80-111 extender card, the I/O board or A/D board may be removed and placed on the extender card instead, without needing to remove the unit cover.

Slow Analog to digital converter output offset nulling procedure.

The 80-D200-006 (A/D) board has an instrumentation amplifier, (U9) used to assist in analog to digital signal conversion. This device is equipped with a nulling potentiometer (R44) across pins 4 and 5. If this signal is not properly nulled, the offset voltage of the amplifier will contribute to a serious calibration inaccuracy at low output voltages.

Example: When the "TEST" switch is pressed, the unit lowest displayed HIPOT output is 140V, the following procedure will reduce the lowest seen voltage to 40V-60V, greatly improving accuracy on voltages below 1000VDC

If the technician does not have access to the Baker Instrument 80-111 digital series extender card,
The top of the unit case will need to be removed as detailed elsewhere.

1) Connect Fluke DMM across U22 pin 9 and GND in mV DC range. Typically, +/- 50mV DC is present. Press "TEST" and hold the test switch to view the CRT and see how much off set voltage is seen.

2) By use of pot adjustment tool at R44, adjust this voltage to +20mVDC +/- 5 mVDC The closer to 0VDC the less offset present.

3) Actual measured voltage: _____mV DC

DC VOLTAGE:

High DC voltages shall be measured with the Fluke 80K-40 or equivalent high voltage probe.
When measurements are indicated, the probe shall be connected as follows:

1) Place the probe into the digital multi-meter, place the multi-meter into the "DC V" setting, power on the meter. Connect the probe high voltage end to test lead "1" and low voltage clip to test lead 'G"

2) Locate the Baker Instrument "FUNCTION" switch, place it into "HIPOT 100uA/div". Locate the Baker Instrument "TEST SELECT" switch, place it into "HIPOT" When the Baker Instrument is energized, high DC voltage can be applied to test lead "1"

3) Apply 85-265 VAC single phase to the power entry module, with a properly grounded three prong cord. Switch the Baker Instrument on.

4) Locate and depress the panel switch "TEST", the Baker Instrument will initiate a DC HIPOT test, locate and depress the panel switch "SLOW UP", the test set will begin to slowly ramp the output voltage.

5) Monitor the voltage applied to the DMM, and release the "SLOW UP" switch when the applied voltage is indicated between 490-510VDC. Take note of the Baker Instrument displayed voltage, it also should be within +/- 5%. If applied voltage is grossly out of range, investigate, troubleshoot and repair as needed. See step (9) for calibration instructions.

6) If applied voltage is within specification (5) again press and hold "SLOW UP" until the indicated potential is 1990-2010VDC, take note of the Baker Instrument displayed voltage, it should be within 5%. If applied voltage is grossly out of range, investigate, troubleshoot and repair as needed. See step (9) for calibration instructions.

7) If applied voltage is within specification(6), again press and hold "SLOW UP" until the indicated potential is 9990-10010VDC, take note of the Baker Instrument displayed voltage, it also should be within 5%

8) If applied voltage is within specification (7) again press and hold "SLOW UP" until the indicated voltage and output reach maximum. Typical values: D6R maximum output: 5800-6800 VDC. D12R maximum output: 11900-12950 VDC. Apply the potential for at least 1 minute. The Baker Instrument should not arc, flash, or spark during this time.

9) Locate potentiometer R16 (50K) on the 80-D200-003 board, the set value will be 10K ohms +- 5%, adjust as needed with a potentiometer adjustment tool. This component sets up a portion of the gain circuitry on instrumentation amplifier U3. By changing the Pot. Resistance, the displayed DC HIPOT Voltage of the tester can be adjusted. Adjust the displayed voltage until it is within 10% at an indicated value of 490-510VDC, then ramp the applied voltage up, until 9990-10010VDC is indicated, displayed voltage should be within 5% of measured value at any displayed voltage between 990-1010VDC and 12000VDC

10) This device may be accessed through the top of the card cage, if the Baker Instrument 80-111 extender card is unavailable. If successful, proceed to following steps

Target Voltage
Actual measured voltage:_____ displayed voltage:_____(500V)
Actual measured voltage:_____ displayed voltage:_____(2000V)
Actual measured voltage:_____ displayed voltage:_____(9000V)
Actual measured voltage:_____ displayed voltage:_____(12000V)
Actual measured voltage:_____ displayed voltage:_____(Maximum)

(+/-5%)

HIPOT DC Current amplifier output offset nulling procedure.

If the Baker Instrument unit has the case top installed, and the following steps indicate the need for re-calibration, remove the 24 screws that hold the top of the enclosure. Remove the enclosure top by lifting it upwards. This will allow technician access to the calibration trimmer potentiometers on the 80-D200-003 I/O board. If the technician has the Baker Instrument 80-111 extender card, the I/O board may be removed and placed on the extender card instead.

The amplifier used to buffer/amplify the low level signals may have an output offset voltage, potentially becoming a source of calibration error in the 1 micro-amp or .1 micro-amp settings

Example: The Baker Instrument is used to perform a HIPOT test at 1000VDC, the unit has nothing hooked to its test leads, and the test leads are clean and well isolated from conductive surfaces. When the voltage is reached and the unit is placed into the .1 micro-amp per division setting, a "false" .3 micro-amp reading is displayed. (The reading should be >50400Meg).

The current amplifier used to buffer/amplify typically needs to be trimmed by the potentiometer R23 on the 80-D200-003 I/O board. Again, this pot may be reached by access holes on the top of the digital card cage. The correct procedure is as follows:

1) Connect Fluke DMM, reading set to milli-volts DC across the test points HIPOT_IVAL and GND. The dc signal present will be trimmed as follows

2) Place "FUNCTION" switch into the .1 micro-amp per division range. (no high voltage output from the unit) "TEST SELECT" switch in "HIPOT" with all four test leads open circuit.

3) The mV (DC) present should be +/- 10mV DC, by use of R23, trim voltage to = +/- 2.5 mV, the observed signal will drift up and down by about 1.5 mV. The idea is to trim as close to zero as reasonably possible.

4) Actual measured output offset voltage: _____mV DC

100 micro-amperes per division range, maximum applied current 1 milli-ampere DC

If the Baker Instrument unit has the case top installed, and the following steps indicate the need for re-calibration, remove the 24 screws that hold the top of the enclosure. Remove the enclosure top by lifting it upwards. This will allow technician access to the calibration trimmer potentiometers on the 80-D200-003 I/O board. If the technician has the Baker Instrument 80-111 extender card, the I/O board may be removed and placed on the extender card instead.

1) Place the Baker Instrument into the "HIPOT" function range 100 micro-amps/division, indicated by the "FUNCTION" select knob.

2) Place the "TEST SELECT" switch into "HIPOT" position.

3) Connect the 10 Megohm resistor across test lead "1" and test lead "G"

4) Apply AC power to the power entry module, and turn the unit "ON"

5) Press and hold the "TEST" switch, the Baker Instrument will initiate a DC HIPOT test, waiting for you to ramp the test voltage

6) Press and hold the "SLOW UP" switch, the DC potential applied will be indicated by the bar graph left side of the Baker Instrument display screen. The voltage will increase as long as the "SLOW UP" switch is pressed. When "SLOW UP" is released, while "TEST" is remained held, the unit output voltage will remain unchanged. Apply 490-510VDC as indicated, when 490-510VDC is displayed release "SLOW UP"

7) With 490-510VDC applied to the 10Megohm resistor, the applied output current will be 49.0 – 51.0 micro-amperes. With the indicated displayed calculated Megohm value being 10 Meg. Take note of the value. Again press "SLOW UP" switch, raise the applied voltage to 7990-8010VDC The

displayed current shall be 750-850 micro-amperes, with a displayed calculated Megohm value of 10Meg. Further increase should cause the Baker Instrument to over current trip, being close to the 1000 micro-amp trip point. Note TRIP POINT in micro-amps:_____

8) Should re-calibration be deemed necessary, the technician responsible shall use the adjustment potentiometer R8 on the I/O board to make the necessary changes. Adjustment of R8 allows increase or decrease of the Baker Instrument 100 micro-ampere/division setting only. Make the indicated adjustments at 490-510VDC, 49-51 micro-amperes and at 7990-8010 VDC, 750-850 micro-amperes.

Target
Actual current: _____ Displayed current: _____(50 micro-amps)
Actual current: _____ Displayed current: _____(100 micro-amps)
Actual current: _____ Displayed current: _____(200 micro-amps)
Actual current: _____ Displayed current: ____ _____(800 micro-amps)

When the calibration accuracy is deemed adequate, the responsible technician shall proceed to the next calibration step, 10 micro-amperes per division.

Note: At any time, the technician shall be able to switch into the coarser ranges while ramping/raising the DC voltage up, allowing the calibration to progress at a more reasonable rate.

Example) The required output current is .5 micro-amp, yet the Baker Instrument HIPOT trips as soon as the "SLOW UP" button is pushed while testing, this is because of capacitive charging current, raising the potential of the test lead, load resistor and the internal capacitance of the unit. Raise the voltage in the 10 micro-amp range, and when the desired voltage is reached switch the unit into the 1 micro-amp, or .1 micro-amp range.

This little table may be a helpful tool to calculate the current through the load resistance

Load	Voltage	Current
1000 MΩ	1 K	1 μA
100 MΩ	1 K	10 μA
10 MΩ	1 K	100 μA

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10 micro-amps per division range, maximum applied current 100 micro-amperes DC.

9) Place the Baker Instrument into the "HIPOT" function range 10 micro-amps/division, indicated by the "FUNCTION" select knob.

10) Place the "TEST SELECT" switch into "HIPOT" position.

11) Connect the 100 Megohm resistor across test lead "1" and test lead "G"

12) Apply AC power to the power entry module, and turn the unit "ON"

13) Press and hold the "TEST" switch, the Baker Instrument will initiate a DC HIPOT test, waiting for you to ramp the test voltage

14) Press and hold the "SLOW UP" switch, the DC potential applied will be indicated by the bar graph left side of the Baker Instrument display screen. The voltage will increase as long as the "SLOW UP" switch is pressed. When "SLOW UP" is released, while "TEST" is remained held, the unit output voltage will remain unchanged. Apply 490-510VDC as indicated, when 490-510VDC is displayed release "SLOW UP"

15) With 490-510VDC applied to the 100Megohm resistor, the applied output current will be 4.9 – 5.1 micro-amperes. With the indicated displayed calculated Megohm value being 100 Meg. Take note of the value. Again press "SLOW UP" switch, raise the applied voltage to 7990-8010VDC The displayed current shall be 85-95 micro-amperes, with a displayed calculated Megohm value of 100 Meg. Further increase should cause the Baker Instrument to over current trip, being close to the 100 micro-amp trip point. Note TRIP POINT:_____

16) Should re-calibration be deemed necessary, the technician responsible shall use the adjustment potentiometer R33 on the I/O board to make the necessary changes. Adjustment of R33 allows increase or decrease of the Baker Instrument 10 micro-ampere/division setting only. Make the indicated adjustments at 490-510VDC, 4.9-5.1 micro-amperes and at 7990-8010 VDC, 75-85 micro-amperes.

Target

Actual current: _____ Displayed current: _____(5 micro-amps)
Actual current: _____ Displayed current: _____(10 micro-amps)
Actual current: _____ Displayed current: _____(20 micro-amps)
Actual current: _____ Displayed current: _____(80 micro-amps)

When the calibration accuracy is deemed adequate, the responsible technician shall proceed to the next calibration step, the 1 micro-amperes per division.

1 micro-amps per division range, maximum applied current 10 micro-amperes DC.

17) Place the Baker Instrument into the "HIPOT" function range 1 micro-amps/division, indicated by the "FUNCTION" select knob.

18) Place the "TEST SELECT" switch into "HIPOT" position.

19) Connect the 1000 Megohm resistor across test lead "1" and test lead "G"

20) Apply AC power to the power entry module, and turn the unit "ON"

21) Press and hold the "TEST" switch, the Baker Instrument will initiate a DC HIPOT test, waiting for you to ramp the test voltage

22) Press and hold the "SLOW UP" switch, the DC potential applied will be indicated by the bar graph left side of the Baker Instrument display screen. The voltage will increase as long as the "SLOW UP" switch is pressed. When "SLOW UP" is released, while "TEST" is remained held, the unit output voltage will remain unchanged. Apply 490-510VDC as indicated, when 490-510VDC is displayed release "SLOW UP"

23) With 490-510VDC applied to the 1000Megohm resistor, the applied output current will be .49 – .51 micro-amperes. With the indicated displayed calculated Megohm value being 1000 Meg. Take note of the value. Again press "SLOW UP" switch, raise the applied voltage to 7990-8010VDC The displayed current shall be 7.5-8.5 micro-amperes, with a displayed calculated Megohm value of 1000 Meg. Further increase should cause the Baker Instrument to over current trip, being close to the 10 micro-amp trip point. Note TRIP POINT:_____

24) Should re-calibration be deemed necessary, the technician responsible shall use the adjustment potentiometer R68 on the I/O board to make the necessary changes. Adjustment of R68 allows increase or decrease of the Baker Instrument 1 micro-ampere/division setting only. Make the indicated adjustments at 490-510VDC, .49-.51 micro-amperes and at 7990-8010 VDC, 7.5-8.5 micro-amperes.

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		Target current
Actual current: _____	Displayed current: _____	(.5 micro-amp)
Actual current: _____	Displayed current: _____	(1 micro-amp)
Actual current: _____	Displayed current: _____	(2 micro-amp)
Actual current: _____	Displayed current: _____	(8 micro-amp)

When the calibration accuracy is deemed adequate, the responsible technician shall proceed to the next calibration step, the .1 micro-amperes per division.

.1 micro-amps per division range, maximum applied current 1 micro-ampere DC.

25) Place the Baker Instrument into the "HIPOT" function range .1 micro-amps/division, indicated by the "FUNCTION" select knob.

26) Place the "TEST SELECT" switch into "HIPOT" position.

27) Connect the 1000 Megohm resistor across test lead "1" and test lead "G"

28) Apply AC power to the power entry module, and turn the unit "ON"

29) Press and hold the "TEST" switch, the Baker Instrument will initiate a DC HIPOT test, waiting for you to ramp the test voltage

30) Press and hold the "SLOW UP" switch, the DC potential applied will be indicated by the bar graph left side of the Baker Instrument display screen. The voltage will increase as long as the "SLOW UP" switch is pressed. When "SLOW UP" is released, while "TEST" is remained held, the unit output voltage will remain unchanged. Apply 490-510VDC as indicated, when 490-510VDC is displayed release "SLOW UP"

31) With 490-510VDC applied to the 1000Megohm resistor, the applied output current will be .49 – .51 micro-amperes. With the indicated displayed calculated Megohm value being 1000 Meg. Take note of the value. NOTE TRIP POINT:_____

32) Should re-calibration be deemed necessary, the technician responsible shall use the adjustment potentiometer R46 on the I/O board to make the necessary changes. Adjustment of R46 allows increase or decrease of the Baker Instrument 1 micro-ampere/division setting only. Make the indicated adjustments at 490-510VDC, .49-.51 micro-amperes.

Do Not Touch Test Leads While Testing is in Progress!

		Target current
Actual current: _____	Displayed current: _____	(.05 micro-amp)
Actual current: _____	Displayed current: _____	(.1 micro-amp)
Actual current: _____	Displayed current: _____	(.2 micro-amp)
Actual current: _____	Displayed current: _____	(.8 micro-amp)

The 10000 megohm resistance, if present, shall be used to make measurements at 1KVDC, 2KVDC and 9KVDC. The results, in Megohms, shall be placed onto the table above.

Open circuit leakage test

The purpose of this test is to check the Baker Instrument for internal electrical leakage. When the DC HIPOT is performed, it is important the electrical leakage of the unit is very low. If there is electrical discharge or leakage inside the unit, a false or erroneous micro-ampere current reading may be obtained. The idea is that leakage current on the display of the Baker Instrument is the electrical leakage through insulation in/of the object under test. (Electric motor/Generator/ winding etc...) Also of importance: The test leads of the instrument may be a source of electrical leakage. This is especially true when the test leads are dirty, and touching a conductive or grounded surface. The D6/12R is capable of making measurements to 50,400 meg-ohms (50.4 Gig-ohms) This means it could be important to take the following steps during testing.

The higher the test voltage, the more likely, leakage current.

33) Elevate the test leads away from the flooring, or other potentially conductive surfaces.

34) Test when the equipment and object under test is at a temperature above dew-point.

35) Place the Baker Instrument into HIPOT Position on the "function" switch 100 micro- amps/div

36) Place the "TEST SELECT" switch into "HIPOT"

37) The test leads shall be isolated from personnel and equipment, a clean, five gallon bucket, plastic pail or plastic wastebasket can be used to elevate the test leads from the flooring.

38) Press and hold "TEST" the Baker Instrument will initiate a HIPOT test.

Do Not Touch Test Leads While Testing is in Progress!

39) Press and hold "SLOW UP" the output voltage will steadily increase.

40) Increase the output of the instrument until 11900-12010VDC is indicated on the display, when the potential is reached, release the "SLOW UP" switch while continuing to hold the "TEST" switch. Now, switch the "FUNCTION" switch into the 10 micro-amp range, then the 1 micro-amp range.

41) When in the 1 micro-amp range, with clean test leads and acceptable internal leakage, the displayed leakage current shall be less than .5 micro-amperes at 12000VDC.

42) If the displayed leakage is less than .5 micro-amperes, switch the instrument into .1 micro-amp pre division setting. Again a value of less than .5 micro-amperes is to be displayed.

Take the final measurement after 1 minute has elapsed, when internal capacitance is fully charged.

Note maximum leakage current .5 micro-amperes at 12KVDC
ACTUAL:_____

High Voltage ARC test, HIPOT trip verification test.

The Baker Instrument has two separate safety over-current trip circuits, used to shut off the high voltage elements of the unit should an over-current situation arise.

RESISTIVE:
Circuit 1: This circuit is located on the 80-D200-003 I/O board, it is a comparator, which reads the current sensed by the instrument in DCV, when the signal HIPOT_IVAL reaches approximately 4.8 Volts the comparator changes state, HIPOTRIP signal then tripping the tester.

TRANSIENT:
Circuit 2: This circuit is located on the "G" test lead, inside the unit. It senses current spikes from high voltage arc's and discharges. These spikes are captured, rectified, optically coupled and used to trip the instrument if an arc occurs.

Further information about this circuit is found in 80-D200-004 Design notes. Specifically HIPOTRIP_OC.

The test shall be performed as follows:

43) Circuit 1 operation has been verified according to steps detailed in 100/10/1/.1 micro-amp per div. calibration.

44) Place the Baker Instrument "FUNCTION" switch into "HIPOT 100uA/Div" With the test leads on an insulating surface, space the test lead "1" and test lead "G" approximately .25" apart. They will form the arc gap.

45) Place the Baker Instrument "TEST SELECT" switch into "HIPOT"

46) Press and hold "TEST" the Baker Instrument will initiate a HIPOT test.

47) Press and Hold "SLOW UP" until a high voltage breakdown occurs across test lead "1" and test lead "G" the tester should arc once, occasionally twice and then HIPOT trip. With the "HIPOT TRIP" lamp illuminated, and "HIPOT TRIP" seen on the display until "TEST" is released.

48) Visually verify that the neon bulb at C1 on the 80-D200-008 discharge board lights up when the HIPOT arc occurs. If the lamp does not glow, it is bad. (any voltage above approximately 2000V will initiate)

When lamp is verified as operational, proceed to the final step, high voltage breakdown

Verify lamp:_____

49) ARC test at least three times, at voltages of 9000-10000VDC. Unit malfunctions, re-setting, or internal arcing are un-acceptable. If problems are encountered troubleshoot and repair.

HIGH VOLTAGE ARC TEST: PASS/FAIL? Initial _____

Surge Calibration

Calibrate each V/Div range for the correct voltage (+/-10%) and wave shaping as described here.

1. Connect a 1 ½ to 2-foot high voltage lead to the high voltage oscilloscope probe and the other end to a 1-5-mH load. Connect lead 1 of the tester to the same place on the 1-5 mH load. Connect the tester ground lead to the other side of the load. Set the oscilloscope to 1 V/div and 2.5 µs. Set the digital tester to 3000 v/div and 2 µs.

NOTE: It will be very helpful to place the I/O board inside the digital card cage, after each range has been adjusted to verify the results. The extender card will affect the calibration somewhat, possibly leading to calibration difficulties and error.

2. Press and hold the "TEST" switch. Press and hold the "SLOW UP" switch. Raise the output voltage, as seen on the oscilloscope to 6000 V. The capacitor's at C4, C5 are used as a wave-shaping element's, vary them up and down to allow the surge pattern to be "Matched" as best as possible to the waveform seen on the oscilloscope. Resistor R64 is used to set the overall amplitude, for the 3000 V/div range.

3. Switch the unit to 2000 V/div and adjust R7 (if needed) to match the 6000 V on the CRT display and oscilloscope. Check to make sure both of the 3000 V/div and 2000 V/div settings are linear at 6000 V output +/- 5%.

4. Adjust the output voltage to 3000 V on the oscilloscope with the unit at 2000 V/div. Switch the setting to 1000 V/div and adjust R6 (if needed) to match the CRT display voltage with the voltage on the oscilloscope. Make sure the 3000 V/div and 2000 V/div are linear at 3000 V output +/- 5%.

5. Turn the voltage down to 1500 V on the oscilloscope with the unit at 1000 V/div. Then switch to 500 V/div and adjust R5 (if needed) to match the CRT displayed voltage to the oscilloscope. Make sure the 1000 V/div and 500 V/div are linear at 1500 V output +/10%.

Range	Test Voltage	Corresponding resistor	Approximate Size Needed
3000 V/div		R64	470 ohm
2000 V/div		R7	2.0 K ohm
1000 V/div		R6	6.2 K ohm
500 V/div		R5	15 K ohm

6. Check again for linearity between ranges and make sure you are within +/- 5% of calibration at higher voltages.
   Initial:_____

7. Be sure to run the surge test to maximum output in all three of the surge lead positions, both shorted, open, and on the load coil. Be sure there is no corona or arcing in the unit. Use RTV silicone to reduce corona on the test select switch and on other points where corona is found.

Do Not Touch Test Leads While Testing is in Progress!

8. Short circuit leads, with all leads shorted together for 1000 pulses:
Initial:_____

9. Open circuit leads, with all leads open, 1000 pulses: Initial: _____

Check and record the following results on the surge load coil:

Oscilloscope with 1000X probe :

	Actual oscilloscope indicated	Baker Instrument display
500 Volts:		
1000 Volts:		
2000 Volts:		
6000 Volts:		
9000 Volts:		
12000 volts:		
Maximum Voltage:		

Function Test

Surge Test, High voltage breakdown test:

This test is performed to simulate the effect of turn to turn short circuit operation.

Perform the test as follows:

10. Connect lead "1" of the tester to the 1-5 mH load. Connect the tester ground lead to the other side of the load. Set the digital tester to 3000 v/div and 10μs.

11. Use a length of high voltage wire with clips on each end to make an ARC gap across lead "1" and the ground lead of the Baker Instrument. The gap shall be approximately 1/4" for the 12KV tester and about 1/8" for the 6KV instrument.

12. Press and hold the "TEST" switch. Press and hold the "SLOW UP" switch. Raise the output voltage at least 80% output. The tester should begin to ARC across the gap with a loud, glowing, electrical discharge.

13. Make sure the tester applies at least 3 ARC's and does not false trigger/lock the micro-processor/re-boot etc…

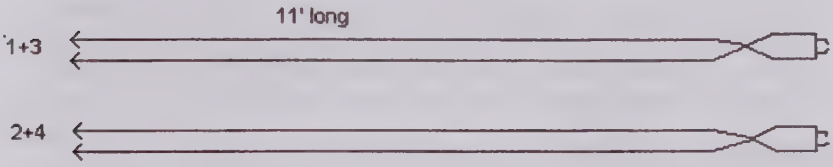
Do Not Touch Test Leads While Testing is in Progress!

14. Record results. Pass/fail? Initial: _____

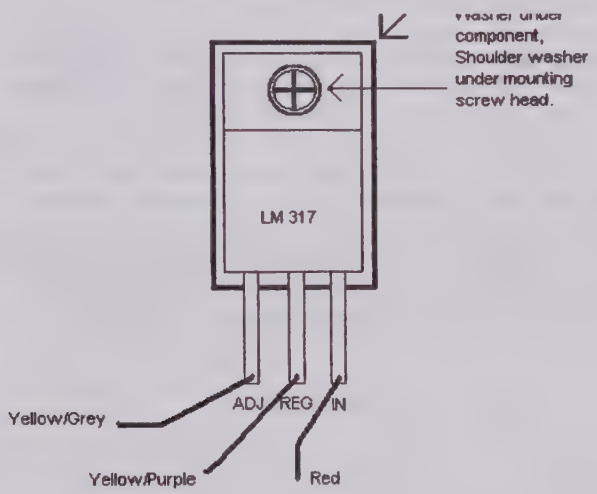
WINDING RESISTANCE

The Kapton/Silicone Insulating washer shall be visually inspected for nicks/cuts/scratches. If any are visible = replace the insulating washer
Q.C. _____ok _____not ok, repaired.

The interconnect cable, and regulator wiring is shown below.



Winding resistance test leads



The winding resistance test function shall be verified according to the following steps:

1. Place the Baker Instrument into "Res 1-2" position on the "Function" knob.

Do Not Touch Test Leads While Testing is in Progress!

2. The CRT screen of the unit will switch into the resistance screen, ready to perform the test.

3. Place a DMM in MV range across A/D board (80-D200-006) pins 8 and 9 on U6, null the voltage present to 10 mV +/- 2.5 mV.

4. Press the "RUNTEST" soft key seen on the CRT. The Baker Instrument should display a value of 216 Ohms (nothing is connected at this time)

5. Connect the resistance test leads across the Fluke DMM with the fluke DMM set-up to measure DC Current, again initiate the sequence. The current source of the D12R will apply 20mA, 200MA and then 2A, the idea here is to make sure these three currents are applied.

RESULTS: Current applied all three ranges? Y/N_____

6. The Baker Instrument will measure the resistance present across the resistance test leads, and display the value on the CRT.

7. The unit will scale the applied current, based upon the voltage sensed at U6 on the A/D board (80-134) What needs to happen is: The output current will need to be trimmed at calibration to allow accurate resistances to be displayed. The reason is: we do not want to change the firmware on every unit. The way to do the test is as follows: See the HVPS controller board schematic, on it you will see the resistance readout and current application circuitry. Each of the three ranges has trimmer potentiometers in it. Press run test, see the current on the fluke DMM, trim with the appropriate pot until it reads the appropriate current and record results. Get the actual current within +/- 5%

RANGE:	ACTUAL CURRENT:
20mA	_____
200mA	_____
2A	_____

8. Later, if range to range calibration is deemed necessary, the resistors R20, R18, R17 and R16 of the A/D board may be changed. These resistors will only affect the appropriate "GAIN" range, i.e. 1, 10, 100 or 1000, they will not influence the actual output from the DC current source.

Do Not Touch Test Leads While Testing is in Progress!

9. Now, the next step is to see what we actually can get showing on the display of the unit. The technician will need to trim the output of the A/D board instrumentation amplifier, used for winding resistance (U6 across pins 8 and 9 with FlukeDMM in mV DC range). Use pot R45 for the trimming of the output voltage with no test being performed. Trim to +/- 10 mV. ACTUAL OUTPUT OFFSET VOLTAGE (mV) =_____

10. Place the .1 ohm precision resistor across the test leads of the Baker, press "RUN TEST".

A value will be indicated, both on the DMM, and presently, the display of the Baker tester.
This is a good starting point, trim as needed to get values within +/- 5%. When properly trimmed, proceed to step 11.

11. If the following values are unavailable, actual ohm values used may be +/-10% and should be noted. Each resistance should be measured 3 times, and the results shown below. The variation between these repetitive tests should be +/- 2%

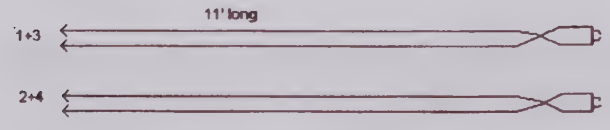
OHMS: 1 2 3

SHORTED:* _____
.031: _____
.051: _____
.102: _____
.202: _____
507: _____
1.006: _____
2.006: _____
5.030: _____
10.028: _____
19.959: _____
90.350: _____
150.28: _____
OPEN: _____

***= For reference only due to resolution limitations**

Do Not Touch Test Leads While Testing is in Progress!

If variations greater than +/-2% are noted, the unit should have Baker Instrument E.C.O #1248 installed. A copy of this ECO is available upon request.



Winding resistance test leads

Any special modifications/options installed must be recorded with appropriate schematic markup's and B.O.M/parts listings. These items shall be attached to this worksheet and filed by serial number in three ring binders.

Place the instrument on heat-run and record the date and start time below (24 Hours on each)

LOW LINE SURGE/HIPOT/RESISTANCE (115VAC or 230VAC.) (If unit is known to be going to an overseas destination country with 230VAC mains, all tests shall be done with 230VAC)

1) SURGE: _____

2) HIPOT: _____

3) RESISTANCE: _____

Restart (if necessary)
LOW LINE SURGE/HIPOT/RESISTANCE (115VAC)

1) SURGE: _____

2) HIPOT: _____

3) RESISTANCE: _____

Do Not Touch Test Leads While Testing is in Progress!

HIGH LINE SURGE/HIPOT/RESISTANCE (230VAC)

1) SURGE: _____

2) HIPOT: _____

3) RESISTANCE: _____

Upon successful completion of heat-run, verify the operation of the unit outputs and safety features. The Baker Instrument is ready for final assembly and installation of the enclosure and the A/D, I/O board panels, appropriate warning labels and the serial number sticker.

File this worksheet in the Digital tester series 2 notebook by serial number.
AT101/Armature test equipped unit:

Units with the AT101 test capability shall be calibrated according to the following steps:

1. Select "AT101" on the "FUNCTION" select switch.
2. Connect the AT101 interface cable to the AT101 connector on the Baker Instrument.
3. Connect the AT101 test head to the end of said cable.
4. Connect a load coil consisting of 2 turns of high voltage cable, with a diameter of about 6"/155mm and alligator clips on the ends, directly across the center brushes on the AT101 test head.
5. Connect the high voltage oscilloscope probe to the AT101 test head as shown.
6. Press and hold the "TEST" switch, the Baker Instrument will initiate an AT101 test.
7. Increase the applied voltage by use of "SLOW UP" until a value of 500 volts is indicated on the oscilloscope.The Baker display will usually be at 10uS/div and 200V/div.
8. Approximate timebase/volts per div will be 2.5 micro-second per division/200mV per division

Do Not Touch Test Leads While Testing is in Progress!

9. Calibration is accomplished at the I/O board, designators C23 and R56. R56 sets maximum value, and C23 sets wave-shape and rise-time.

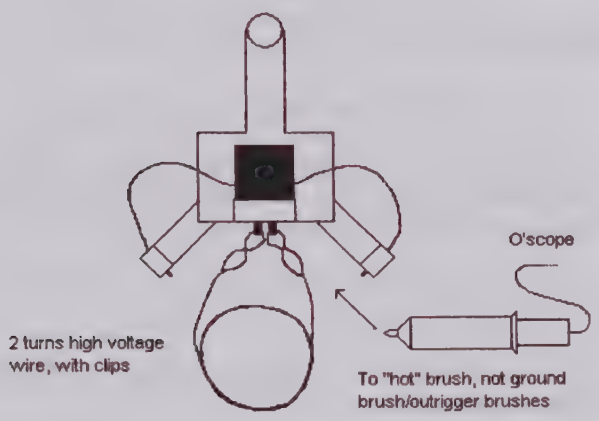
10. Check and record the following results on the 2 turn coil:

11. Oscilloscope with 1000X probe. Voltage accuracy is specified at +/- 10%

	Actual oscilloscope indicated:	Baker Instrument display:
250 Volts:		
500 Volts:		
Maximum Voltage:		

10) Full output 1000 pulses. Initial: _____
11) Full output 1000 pulses with 2 turn coil removed. Initial: _____

AT101 TEST HEAD EXAMPLE



PP30 function test:

Make sure to connect the D6/12R testers to a function PP30D tester, or a test jig (if available) that will allow the I/O functions to be checked.

The D6/12 shall enable the PP30 and perform a surge/hipot test

Do Not Touch Test Leads While Testing is in Progress!

1) Surge test: _____
2) Hipot Test: _____
3) 100 uA/div:_____
4) 10 uA/div: _____
5) 1 uA/div:_____

All units shall pass these tests before shipment.

Do Not Touch Test Leads While Testing is in Progress!

Do Not Touch Test Leads While Testing is in Progress!

SUPPLEMENT ONE: PP130/PP230 POWER PACK

Inside.....

- Initial Set-Up
- Power Pack Operation

Do Not Touch Test Leads While Testing is in Progress!

Do Not Touch Test Leads while test is in Progress!

The use of the PP130/PP230 Power Pack incorporates a system of two separate units; a 12 kV host unit (the Digital Tester) and a 30 kV power pack. The 12 kV portion of the system is capable of stand alone operation for Surge or DC Hipot test functions. The power pack relies on the 12 kV host unit to provide triggering and readout functions and cannot operate alone.

Instructions for stand alone operation of the 12 kV host unit should be reviewed in the main portion of this manual before attempting operation with the 30 kV power pack. This supplemental manual will provide instruction on how to correctly set up, connect, and operate the power pack, and other important safety information.

Caution

Never attempt testing a load with both 12 kV and Power Pack test leads attached to the load at the same time!

Note: The ground fault system on the 12 kV host tester will render it inoperative without a proper ground. When the host tester is connected to the PP130/230, any inoperable condition will also affect the power pack due to loss of the surge enable signal.

These instruments should never be used without a grounded supply.

Caution Notes

- User safety demands that the tester output NEVER be activated without connection to a winding load of some type. Please refer to the host tester instructions in the main portion of this manual for connection procedures to various windings.

- Remember: The host testers VOLTS/DIV switch affects only the display amplitude on the CRT. It does not control or limit the output voltage of the host unit or power pack in any way.

Emergency Shut Off Button

The 30 kV power pack is equipped with a large, red Emergency Shut-Off button on the front panel of the unit. It is located to the right of the TEST button. Use it to quickly discontinue a test and to shut off all power to both the power pack and the Digital Tester.

The emergency shut-off button is a two position switch. While in the IN position, power is supplied to both the power pack and the Digital tester and testing can proceed as normal. When put into the OUT position by pressing it once, any test that is in progress will immediately stop and the power to both units will turn off.

To resume testing with the power pack and/or the Digital tester, depress the emergency shut-off button again (it must be in the IN position). The ON/OFF switch lights of both units will turn on. Follow the procedure for Power Pack Operation to follow.

Initial Set-Up

These instructions refer to the PP130/230 VAC Power Pack. Instructions are identical for the PP230/240 VAC power pack.

1. Connect the power pack to the tester. Use the short AC line cord on the power pack front panel to connect to the 12 kV host tester power entry receptacle (LINE IN).

2. Connect the 25-pin interconnect cable between the front of the two units. The cable is marked on each end. Be sure to plug in the end marked HOST into the Auxiliary port (AUX) on the front of the Digital Tester panel and the end marked 30KV into the Auxiliary port (AUX) on the front of the Power Pack.

3. Connect the long AC power cord to the power pack front panel receptacle and then to an appropriate AC power source. For 220/240 Volt Power Packs, please see NOTE REGARDING 220/240VAC UNITS concerning AC line cord connectors.

Both units are now ready for operation.

The host tester is equipped with a ground fault monitor and indicator. This circuitry should not hinder operation of GFI protected AC power circuits.

Do Not Touch Test Leads while test is in Progress!

If you find that a problem exists, the internal ground monitoring circuit may be disabled. Please call Baker Instrument Company's Service Department at 800-752-8272 for assistance. The ground fault monitor must also be disabled in the event that the unit is to be operated on a transformer isolated AC circuit. Failure to do so will cause a loss of ground indication, disabling the high voltage power section of the unit. Please assure safe operating practices whenever disabling the ground monitor circuit! It is advised that some type of external grounding strap be used.

Power Pack Operation

Surge Testing

1. Power-up the 30 kV power pack and host tester. Follow the host tester set-up procedures in this manual (refer to Single Coil Surge Test and Set Up or Three Phase Motor Surge Test and Set Up)

Note: The PP130/230 requires a one to two minute warm up prior to operation.

2. Set the 12 kV host tester FUNCTION control switch to AUX (auxiliary) position.

Note: The volts per division setting when the AUX is selected will change the Volts/Division setting from 500, 1000, 2000, 3000 Volts/Div to 1250, 2500, 5000, and 7500 Volts/Div. The 1250 Volts/Div setting is not available with the PP130/230 and an error message will appear on the display when this setting is selected. Use 2500, 5000, and 7500 Volts/Div only.

3. Assure the power pack OUTPUT control is at MIN, (full counter-clockwise).

4. Connect the power pack leads to the appropriate load. See Lead Connection for proper test lead connection.

Note: It is important to connect the safety ground (the smaller diameter black ground lead) to the frame of the test winding and NOT to the coil ground lead. Results of the surge test will be erroneous if the coil ground lead is used instead of the frame for grounding.

Do Not Touch Test Leads while test is in Progress!

CAUTION

High Voltage ACTIVATION is next! Ensure that all personnel are away from the device under test and are not in contact with either load or test leads!

WARNING

Some test leads will be open during the test and can be at the same voltage potential as the winding! All precautions should be made to avoid touching these leads.

5. Start test by depressing the power pack TEST switch (or FOOTSWITCH) and slowly raise the power pack OUTPUT control. A pattern should immediately be visible on the display screen of the host tester. If not, recheck the connections and all the switch settings. Also assure that the interconnect cables have been attached and are secure.

6. The display may require adjustment for optimum clarity, sweep and positioning. Make any adjustments required prior to continuing the test.

7. Determine your test voltages and adjust the VOLTS/DIV setting so that the waveform is fully displayed without going off the screen.

8. When the test is complete, release the TEST switch of the power pack and return the OUTPUT control to its minimum setting.

9. Store the wave patter into the internal memory of the host unit, or onto a computer connected to it. See Storage and Print Capabilities.

10. Reposition the red (HOT) and black (GROUND) test lead, previously connected to the leads of the windings. Refer to Lead Connections. Compare all phases against each other: #1 vs. #2, #2 vs. #3, and #3 vs. #1. By switching one hot and the ground lead each time, the operator can make all the measurements necessary for these comparisons. The operator may find it advisable to mark or identify the stator leads at the time of, or prior to the first test.

NEED 3 PHASE SWITCH DESCRIPTION

Lead 1	Lead 2	Lead 3
Hot	Ground	Ground
Ground	Hot	Ground
Ground	Ground	Hot

DC Hipot Testing

1. Power-up the 30 kV power pack and host unit. Follow host tester set-up procedures in this manual (Refer to DC Hipot Test and Set-Up)

2. Set the host units FUNCTION switch to the AUX setting. Set the 30 kV Power Packs FUNCTION switch to the HIPOT setting.

Note: As the Power Pack FUNCTION switch is changed to the HIPOT setting, a loud relay noise will be heard. This is normal for the Power Pack.

3. Connect the red (HOT) lead from the power pack tot he winding to be tested, and the black (GROUND) leads to the iron or core material.

4. Begin testing y depressing the power pack TEST switch and slowly increase the OUTPUT control.

As the OUTPUT is increased, the Voltage Bar rises up slowly and the Current Bar rises rapidly on the right side showing the charging current. When the OUTPUT is held at a given voltage setting, the Current Bar will fall and remain at a constant level to indicate the leakage current.

Note: This test should e interrupted any time a fast, sharp rise in the current is observed.

Note: The over-current Hipot trip levels that activates the HIPOT TRIP light are ten times the micro-amps/division settings on the tester. The trip levels are 10,100, 1000 micro-amps. Releasing the TEST button will reset the over-current trip to begin testing again.

5. Adjust VOLTS/DIV and µAMP/DIV to best monitor the voltage and current levels. Note the voltage, resistance in mega-ohms, and leakage current levels displayed on the screen.

Do Not Touch Test Leads while test is in Progress!

6. When the desired test voltage has been achieved, press the TIME=0 FUNCTION button (the right most button above the CRT display). The elapsed time displayed in the upper left corner of the screen will reset to zero.

Note: Use TIME=0 function to be sure the full DC voltage potential is applied for the required test time. In this way, the time required for voltage ramp-up will be discounted for both Hipot and Polarization Index tests.

7. Upon completion of the test, return the OUTPUT control to MIN and release the TEST button. If desired, store the hipot data into the internal memory of the host unit. See Storage and Print Capabilities.

Note: Always allow a sufficient time for the winding under test to completely discharge before disconnecting the test leads. The recommended practice is to discharge the winding for a duration of at least five times the duration of the DC Hipot test for high voltage windings.

CAUTION

Disconnect the units test leads not being used from the load.

NEVER USE THE HOST UNITS GROUND LEADS FOR GROUNDING DURING THE 30kV POWER PACK TEST!

Note: For Hipot operation of the 12 kV host tester alone, the host tester and the power pack must be disconnected from each other.

For Surge operation of the 12 kV host tester alone, the operator need not disconnect the two units. Simply place the 12 kV host unit FUNCTION switch back to the SURGE position. The host unit is now ready to Surge test alone.

Lead Connection

New

RED = Hot lead
BLK/BLU = larger diameter black ground lead with blue braided cover
SM BLK = smaller diameter black ground lead

Note: It is important to connect the safety ground (the smaller diameter black ground lead) to the frame of the test winding and NOT to the coil ground lead. Results of the surge test will be erroneous if the coil ground lead is used instead of the frame for grounding.

Note: Some test leads will be open during the test and can be at the same voltage potential as the winding! All precautions should be made to avoid to touching these leads.

Single Phase Lead Connections

	Lead 1	Lead 2	Lead 3	Frame
Test Phase 1	Red	Blk/Blu	Open	Sm Blk
Test Phase 2	Open	Red	Blk/Blu	Sm Blk
Test Phase 3	Blk/Blu	Open	Red	Sm Blk

	Lead 1	Lead 2	Lead 3	Frame
Test Phase A	Red	Blk/Blu	Open	Sm Blk
Test Phase B	Open	Red	Blk/Blu	Sm Blk
Test Phase C	Blk/Blu	Open	Red	Sm Blk

*(Phase A = L1 – L2; Phase B = l2 – L3, Phase C = L3 – L1)

Three Phase Lead Connection

Motor Leads	Lead 1	Lead 2	Lead 3	Ground
Surge Lead 1	Hot	Grd	Grd	Blk
Surge Lead 2	Grd	Hot	Grd	Blk
Surge Lead 3	Grd	Grd	Hot	Blk

Do Not Touch Test Leads while test is in Progress!

Connect the safety ground (the smaller diameter black ground lead0 to the frame of the test winding and NOT to the coil ground lead. Results of the surge test will be erroneous if the coil ground lead is used instead of the frame for grounding.

You will be required to manually connect the windings under test once, and you can then apply the different tests to all of the phases of the test object remotely, negating the need for manually-switched test operations.

Note Regarding 220/240 VAC Units

220/240 VAC input units may require the user to supply an appropriate AC connector for mating to the power source. These units are designed for use on a single (1) phase, 220240 VAC power source. Split phase AC power sources will not work. Color codes for the AC line cord supplied are as follows:

Brown	AC Line Hot
Blue	AC line Neutral
Green/Yellow	AC line Ground (earth)

Output Configuration

- Three Red output cables, with insulating jacket rated at 60 KVDC, appropriately marked.
- One Black ground cable, also with insulating jacket rated at 60 KVDC, appropriately marked.

Output During Testing

Hipot: Test lead 1 energized, leads 2 and 3 open connections.

Surge Lead 1: Test lead 1 energized, leads 2 and 3 grounded.

Surge Lead 2: Test lead 2 energized, leads 1 and 3 grounded.

Surge Lead 3: Test lead 3 energized, leads 1 and 2 grounded.

Do Not Touch Test Leads while test is in Progress!

Note: The Power Pack control panel FUNCTION switch must be placed into the Hipot position when you wish to perform a Hipot Test. Be sure to switch the Power Pack test lead selector switch into the Hipot position.

Be sure NOT to switch the Test Lead Selector switch while a test is in progress. The useful life of the switching element may be substantially reduced.

Operating Position

The Power Pack, when equipped with the Three Phase Selector Switch option, is NOT rated for operation in any position other than vertically, with all four wheels, down, on a level surface.

Shipping

The Power Pack, when equipped with the Three Phase Selector Switch option, is NOT rated for shipment in any other position than vertical, with all four wheels, down, in a suitable shipping crate.

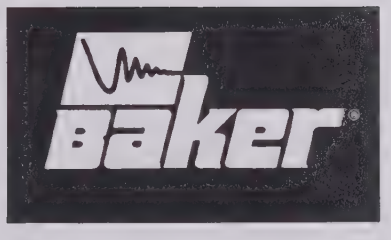
When shipped, the Power Pack must be properly labeled with THIS SIDE UP warning labels.

Do Not Touch Test Leads while test is in Progress!

SUPPLEMENT TWO MTA FOR WINDOWS

Inside.....

- Installation of MTA
- Getting Started
- Testing & Recording Data
- Saving & Reviewing Data



Do Not Touch Test Leads while test is in Progress!

Installation

Configuring the PC's Parallel Port

Computer Bios Settings

The parallel port on the PC used with MTA for Windows must be set up in order for MTA to transfer real time surge data. The parallel port must be configured as an ECP parallel port in the computer's BIOS or on the parallel port card. Consult the PC's manuals for instructions on how to configure parallel ports.

Rebooting the computer is necessary for BIOS setting modification. Using the computer specific keystroke from your PC's manual, check the BIOS settings prior to Windows 95/98 or Windows NT restarting. This specific keystroke enables the BIOS program, which is used to setup the parallel port. This keystroke varies from one computer to another. Many computers use "Del", "Esc", or the "F10" key. Most computers in use today use the BIOS written by Award or Phoenix Technologies. Modification instructions for BIOS settings can be obtained from their associated web sites. They can be reached at www.award.com and www.phoenix.com.

Installing MTA for Windows 95/98

To install MTA for Windows, insert Disk 1 of the distribution disks in the PC's 3-½" floppy drive and run a:\setup.exe. The install program will guide you through the installation process. The files installed include the Digital MTA executable, the dynamic link libraries from Microsoft that allow MTA for Windows to run, the ODBC (Open Database Connectivity) library files, and a folder for saving test data.

To use an existing Digital Tester with MTA for Windows, a new EPROM may need to be installed on the controller board of the Digital Tester. See Appendix I for instructions on determining what type of firmware the tester has. Then if needed see Appendix II for instructions for installing the EPROM. Feel free to call Baker Instrument Company with any questions.

Windows 95/98 Installation Checklist

1. Change the computers BIOS settings for the parallel port to ECP or Bi-directional.
2. Verify the firmware on the Digital Tester to be Version 1.37.
3. Install MTA for Windows with supplied program disks.
4. Run MTA for Windows.
5. Select the proper parallel port under the File menu.
6. Begin using MTA for Windows.

Installing MTA for Windows NT

To install MTA for Windows, log in as the system's Administrator, insert Disk 1 of the distribution disks in the PC's 3-½" floppy drive and run a:\setup.exe. The install program will guide you through the installation process. The files installed include the Digital MTA executable, the dynamic link libraries from Microsoft that allow MTA for Windows to run, the ODBC (Open Database Connectivity) library files, and a folder for saving test data.

To use an existing Digital Testers with MTA for Windows, a new EPROM may need to be installed on the controller board of the Digital Tester. See Appendix I for instructions on determining what type of firmware the tester has. Then if needed see Appendix II for instructions for installing the EPROM. Feel free to call Baker Instrument Company with any questions.

Printer Settings

Printers for Windows NT ***cannot*** be directed to the parallel port being used for communicating to the Digital Tester. For users of Windows NT, press **Start – Settings – Printers** to see which printers are installed on the PC. Right mouse button click on each printer and select the **Properties** option. Select the **Ports** tab on the next display and verify that the parallel port MTA for Windows is using does not have a printer assigned to it. If necessary, redirect printers to an unused port. Often it makes sense to create a "NULL" port where installed printers can be directed.

If only one port is available, redirect the printers to a different port than LPT1 while testing with MTA. After testing with MTA, re-direct the printer to LPT1 for printing. Installing a second ECP parallel port in an open slot on the

computer is another option. ECP parallel port cards form SIIG (www.siig.com) work well with MTA for Windows.

Baker "parallel.sys" Parallel Port Driver

Baker has written a kernel level driver closely based on Microsoft's parallel.sys driver. The MTA for Windows installation program automatically installs the Baker driver in the c:\winnt\system32\drivers folder. The Baker driver is also called parallel.sys, the same name as the Windows driver. Thus, when the machine boots, the Baker parallel.sys is loaded instead of the driver supplied my Microsoft. If for some reason, printing difficulties are encountered while the Baker driver is active; the original NT parallel.sys might have to be manually re-installed over the Baker driver (the MTA for Windows installation program saves the distribution version of parallel.sys). Every effort has been made to print normally with the Baker driver. However some printing problems might arise.

Windows NT Installation Checklist

1. Change the computers BIOS settings for the parallel port to ECP or Bi-directional.
2. Verify the firmware on the Digital Tester to be Version 1.37.
3. Install MTA for Windows with supplied program disks.
4. Reboot computer to load the Baker parallel.sys driver.
5. Redirect any installed printers to a different port than MTA for Windows is using.
6. Run MTA for Windows.
7. Select the proper parallel port under the File menu.
8. Begin using MTA for Windows.

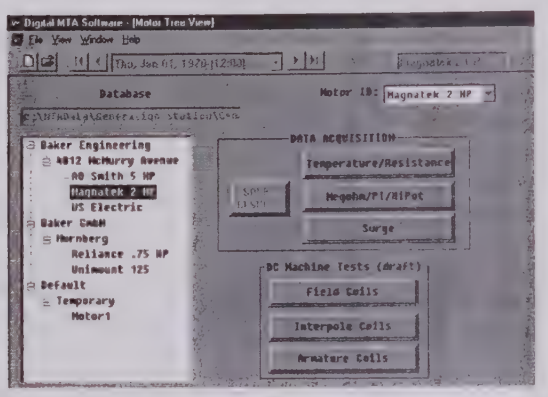
Getting Started

Starting MTA for Windows

To start MTA for Windows, go to the **Start Menu – Programs – Digital MTA** or use the Windows Explorer and double click on the DigitalMTA.exe file in the C:\DigitalMTA folder. The first time MTA for Windows is started a database will need to be created. Enter a new database name of choice. For example: call this new database "first". Subsequent starts of MTA for Windows will

automatically open the database last used. If converting MTA 5.0 databases for use with MTA for Windows please see Appendix II for directions.

Motor Tree View



Upon starting the program the database last used will be presented on the screen. The main tree displays a complete list of motors located in this database. This list sorts all entries by the motors' building and location. Located on the right of the view screen are the buttons for the data logging screens. Pressing these buttons brings you to the test/data logging dialogs.

Selecting a Database

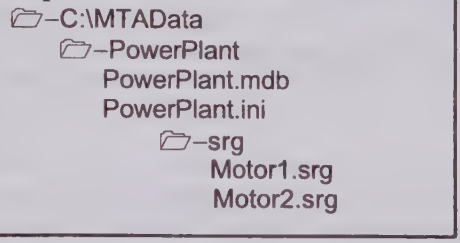
To select a different database, click the **File** menu item and select the **Open** menu option. From the dialog window you can select a database from anywhere on the computer's hard disk. **Note: Databases may only be opened from the Motor Tree View. For convenience purposes it is beneficial to have all databases reside in the MTA Data Folder.**

Creating a New Database

To create a new database click on **File** and select **New** from the menu while in the **Motor Tree View**. A dialog box will be displayed for entry of the name of the new database. A new folder under the C:\MTA Data folder will be created with the name of the new database. The new .mdb database file will reside in this folder. There will also be a **\srg** folder created which stores all surge files associated with this database. The **\srg** folder will be created under the database folder. If the database is moved for some reason, be sure the \srg folder is moved with the database folder.

Do Not Touch Test Leads while test is in Progress!

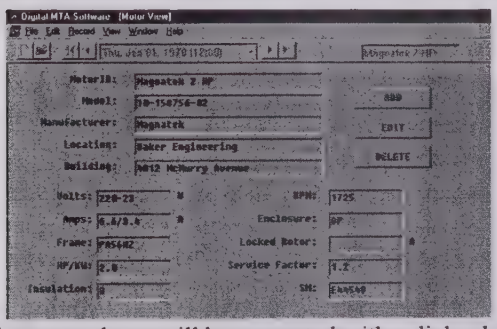
Example folder structure



Note: Organize and name the databases in some sort of groupings that make sense to you. For example, place all the tests done on motors in a particular area of the plant in one database, while motors from another area of the plant go in another database. If testing motors in a rewind shop, make a database for each customer.

Selecting a Motor to Test

The motor tree in the opening window of MTA for Windows sorts motors based on their location and building. After a motor is identified in the tree, double click on the motor's name. That name will then appear in the Motor ID field above the test dialog buttons.



To edit properties of a motor or add a new motor, select the **View** menu from the top of the screen. Click on **Motor View.** From this screen edit the current motor's location, building, and name plate data, delete the current motor, or create a new motor in the database. Press the **New** button and you will be presented with a dialog box to insert information pertaining to the new motor.

To return to the main test screen select **View-Motor Tree View.**

Do Not Touch Test Leads while test is in Progress!

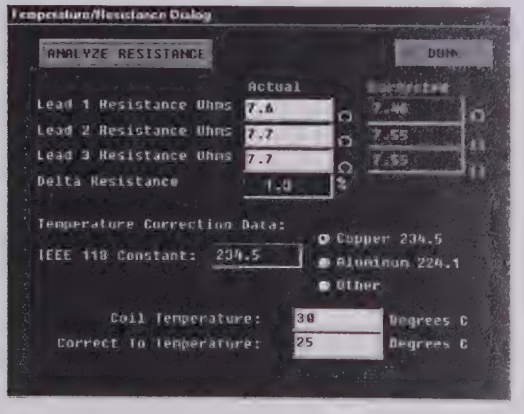
Testing & Recording Data

General Idea of Testing Motors

After selecting a motor to test from the database, perform the tests and save data in the database. Press the **Save Results** button to the left of the test buttons when the desired tests are completed. Most test procedures dictate that the coil resistance test be done on a motor first, followed by a Megohm and PI, then an HiPot test, and finally the Surge test. Normally, only at the end of these tests would the **Save Results** button be pressed; however, you may save individual tests.

Analyzing Coil Resistance Data

The Digital line of Baker surge testers does not have a built in ohmmeter. However, knowing the coil resistance of a motor is an important piece of information to measure and record along with HiPot and Surge data. Therefore, the MTA for Windows provides a dialog window to record resistance measurements obtained with a hand held ohmmeter or precision resistance bridge.



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Press the **Temperature/Resistance** button and you will be presented with a dialog window where resistance data is entered. Once resistance values have been entered, perform temperature compensation calculations on the entered values. Specify the **Correct to Temperature** and the IEEE 118 constant used for the calculation. Press **Analyze** to start the calculation. Results will be displayed to the right of the resistance values.

Coil Resistance Testing Checklist

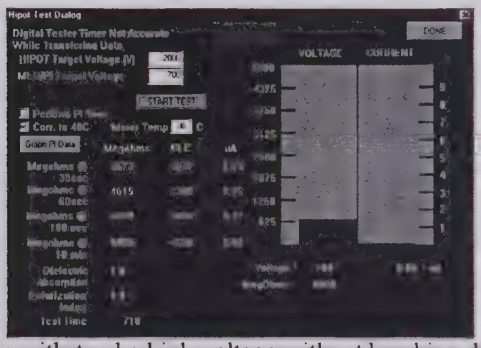
1. Enter coil 1 resistance.
2. Enter coil 2 resistance.
3. Enter coil 3 resistance.
4. Enter 30° C for the **Coil Temperature**.
5. Enter 25° C for **Correct to Temperature**.
6. Press the **Analyze Resistance** button. Corrected Resistance values will be displayed in the right hand column of the window.

You can change the **Coil Temperature** or **Correct to Temperature** and re-analyze/re-calculate coil resistances indefinitely.

When the resistances are properly recorded and analyzed, press the **Done** button to close this dialog window. Go to either the Megohm, PI, HiPot or Surge test. Return to the Temperature/Resistance dialog window at any time to review resistance entries. Pressing the **Save Results** button, will save the data and initialize all test data to zero. After pressing the **Save Results** button, the resistance data collected can be recalled from the database by going to the **View-Results View** menu item. Resistance values may also be edited and re-analyzed in the Results View.

Recording High Voltage DC Test Data

From the **Tree View** press the **Megohm/PI/HiPot** button. From this window record high voltage DC test data. Connect the motor to the Digital tester and set the knobs as instructed in your Digital Tester's manual.



Next enter the Megohm/PI and HiPot target voltages appropriate for the motor being tested. The following is a brief discussion of the different types of DC tests that can be performed:

HiPot tests are usually performed as a proof that the insulation system in the motor can withstand a high voltage without breaking down or exhibiting an unreasonable leakage current.

Megohm tests are performed in order to measure the insulation resistance of a motor. The Megohm test is usually done at a low voltage - approximately the operating voltage of the motor. Consult IEEE 43 and IEEE 95 for the appropriate Megohm test voltage.

PI tests are performed in order to measure the polarizability of a motor's insulation. Almost all insulating materials change their atomic/molecular properties in the presence of high DC electric fields. The polarizability of the insulation materials used in electric motors is measured or quantified with the PI test. This test is performed at lower voltages, often the same voltage used for the Megohm test, and for a duration of 10 minutes. Consult IEEE testing standards for determining the proper PI test voltage for the motors.

DA (dielectric absorption) tests are similar to the PI test. However, the test duration for a DA test is only 3 minutes.

NOTE: The clock displayed on the CRT screen of the tester will not be accurate while communicating with a PC.

Do Not Touch Test Leads while test is in Progress!

High Voltage DC Tests Checklist

1. Set up the Digital tester to perform high voltage DC tests as instructed in the Digital Tester's manual.
2. Enter the appropriate Megohm/PI and HiPot target voltages for the motor.
3. If a PI test is desired, check the **Perform PI Test** check box .
4. If temperature corrected Megohm calculations are desired, check the **Correct to 40C** box and enter the Motor Temperature.
5. Press **Start Test** button, and then quickly depress **Test** button on the Digital tester.
6. Slowly increase voltage with the Output Control knob on the digital tester. The voltage and current will be displayed as blue and red bars on the screen of the computer. If these bars do not appear after 4-5 seconds, release the Test button, turn the output voltage knob down to zero, and repeat the step above.
7. Increase the voltage to desired level. If a Megohm/PI target voltage has been set on the test screen, increase the voltage until just exceeding this target voltage. A red message will appear at the top of the test window indicating the Megohm/PI target voltage has been reached.
8. Adjust u-Amps/div knob on the Digital Tester to best match the leakage current of motor being tested.
9. Hold the **Test** button for the required amount of time for the test to elapse. One minute is required for a Megohm test, three minutes for a DA test, 10 minutes for a PI test. A foot switch is available for holding the **Test** button for the longer tests.
10. After the Megohm/PI test time elapses and the PI display disappears, change the u-Amps/div knob to the 100uA/div setting.
11. Increase the voltage until just exceeding the HiPot target voltage. A red message will appear at the top of the test window indicating the HiPot target voltage has been reached.
12. Re-adjust the u-Amp/div knob to best match the leakage current.
13. After the prescribed amount of time has elapsed for the HiPot test, release the **Test** button on the Digital Tester. The values of current and voltage when the **Test** button is released become the HIiPot measurement values. Once again, consult IEEE 43 and IEEE 95 for recommended HiPot test times. A few seconds after **Test** button has been released; the PC will be ready to respond to commands. During this time, the PC is still communicating with the tester.
14. If satisfied with the test results, press the **Done** button and return to the Motor Tree View.

Do Not Touch Test Leads while test is in Progress!

15. In the **Motor Tree View**, press the **Save Results** button to save the Megohm/PI/HiPot test data or proceed with either the Resistance test or the Surge test. Normally, the Surge test will be performed next.

16. **NOTE: At the end of a HiPot test, a message on the CRT screen of the Digital Tester will indicate an error in the transmission has occurred. This is normal: all real time Megohm/PI/HiPot tests end with this message.**

17. **NOTE: Keep your main attention on the Digital tester. Occasionally glance at the computer's screen to insure that the data logging process is proceeding properly.**

18. If the calculation of the insulation resistance at 40°C is desired, check the **Corr. to 40°C** box prior to starting the test. Temperature compensation calculations will then be performed and results displayed automatically as the test proceeds.

19. On the right side of the HiPot test screen, a graphic is displayed showing a representation of the applied DC voltage and the measured leakage current. A blue slider bar moves up and down with applied voltage while a red slider bar moves up and down with current. If knob settings change, the scales automatically change on the display.

20. During the test a table is filled out on the left side of the screen. Megohm values, leakage current, and temperature compensated megohm values are displayed at 30 sec, 60 sec, 180 sec, and at 10 minutes. **NOTE: The test must run long enough to fill out the table with the required information.** The PI test requires 60 seconds. The Dielectric Absorption test requires 180 seconds (3 minutes). The PI test requires a full 10 minutes.

21. To perform a PI test, check the **Perform PI Test** checkbox. Eighty (80) seconds after reaching the Megohm/PI target voltage, a PI display window will appear and the megohm value and measured current will be displayed in a table on the left side of the PI display. On the right side of the PI display, a graph is presented with a running graphical display of the megohm values and the leakage current values. Upon completion of the PI test, the test voltage may be increased and a HiPot test performed.

22. It is not required to check the **Perform PI Test** button to do a PI test. By running a HiPot test for 10 minutes a PI measurement is automatic whether or not the checkbox was selected.

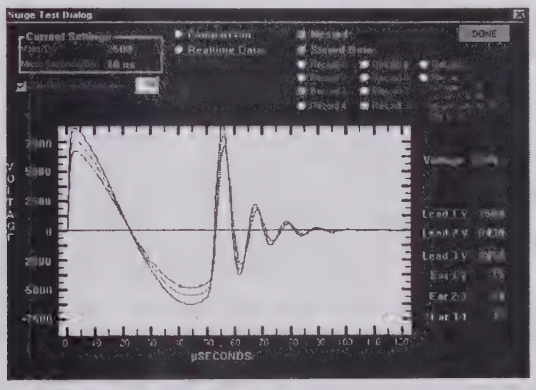
Do Not Touch Test Leads while test is in Progress!

23. At the end of the 10 minute PI test, the PI display will disappear (if the Perform PI Test check box was turned on). A HiPot test may immediately follow without releasing the Test button on the Digital Tester. Follow steps 10-15 above to perform the HiPot test. In this way, all three types of high voltage DC tests can be performed on a motor at one time.

24. After the Megohm/PI/HiPot tests have been completed and satisfactory results have been recorded, press the **Done** button in the upper right corner of the HiPot test window.

Recalling Stored Surge Data

To bring up the surge test dialog window press Surge button on the Motor Tree View.



Data can be retrieved from the tester in either real-time or from the tester's memory.

Do Not Touch Test Leads while test is in Progress!

To Retrieve Stored Surge Data:

1. Press the **Stored Data** radio button

2. Select the record to be retrieved. The PC will transfer data from the tester.

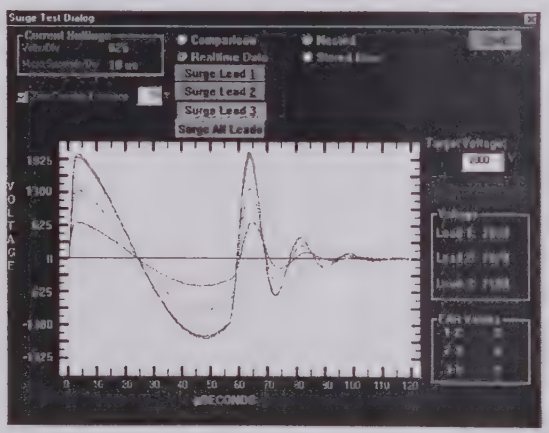
3. Surge waveforms will be displayed on the surge graph and HiPot/PI data associated with the chosen record. This will be displayed on upper right side of the screen.

4. If knob settings for all three waves are the same, EAR will be calculated for the three waves. If the knob settings are different, a message box will pop up and the EAR will not be calculated.

5. Press the **Done** button to return to the **Motor Tree View**.

In the Motor Tree View either save the data by pressing the **Save Results** button or proceed with one of the other tests. Usually, recorded data is transferred to MTA for Windows after scheduled testing is complete. Each stored data record corresponds to a different motor. If a motor does not exist in the database, create it by using the motor view to add it to the appropriate database. Regardless, take care to insure the proper data record ends up in the correct motor's database.
By selecting **Real Time Data** radio button, data from the Digital tester will be transferred from tester to PC after each surge pulse is applied to motor (See: Recording Real Time Surge Data).

There are two modes of retrieving data in real-time: 1) **Comparison Mode** and 2) **Nested Mode**. In **Comparison Mode**, the results from surge testing Lead 1 will be compared to the surge tests of the other leads after Lead 1 has been



Do Not Touch Test Leads while test is in Progress!

tested. In **Nested Mode**, the (1/3) Target Voltage, (2/3) Target Voltage, and (3/3) Target Voltage will be saved as the test for a particular lead progresses. The waveforms for each of these voltages for the lead will be displayed at the end of the test along with the waveform of the maximum voltage reached.

In either Comparison or Nested Mode, if a turn-to-turn short is detected, the waveform of the failed pulse and the previous waveform will be displayed. The locations of the zero crossings will be pointed out with blue arrows.

Turn on the zero crossing error detection by checking the check box labeled **Zero Crossing Tolerance**. The number to the right of the Zero Crossing Tolerance label determines how far a zero crossing must jump before a shift is determined to be a turn-to-turn short. The Zero Crossing Tolerance is roughly the percentage of the width of the display. The default value of 10% corresponds to about 10% of the width of the displayed waveform.

NOTE: If the desired results are to compare windings to each other (as is done in a motor rewind shop) the Comparison Mode would be the mode to use. If testing a motor for preventive maintenance purposes, the Nested Mode would be the best choice.

Recording Real Time Surge Data

1. Select Comparison or Nested Mode.
2. Set Target Voltage to maximum voltage of test.
3. Connect Tester to motor as prescribed in the Digital Tester's manual.
4. Set knobs and selector switch to Lead 1 as described in the Tester's manual.
5. Select Surge Test Lead 1 radio button.
6. Quickly press tester's Test button. You will have about 10 seconds between pressing the radio button and pressing the Test button on the Digital tester.
7. Slowly turn up Output Control knob until the desired test voltage is reached. While increasing the voltage, watch the surge waveform display on either the PC or the Digital Tester looking for indications of a turn- to-turn short. See the Digital Tester's manual for information on identifying turn-to-turn shorts.

Do Not Touch Test Leads while test is in Progress!

8. Release the Test button when the target test voltage is reached or a turn-to-turn fault is detected.

9. The surge test screen will then show the final display for either Comparison or Nested Mode.
10. If the Seconds/div knob or Volts/div knob need to be changed to fully display the surge wave, make any adjustments then repeat procedure above for capturing data.
11. Select Lead 2 on the Tester's rotary switch, select the Surge Test Lead 2 radio button.
12. Quickly depress the Test button on the Tester.
13. Increase the voltage looking for waveform shifts indicative of winding faults.
14. Repeat the same procedures for Lead 3. After all three leads have been tested, the EAR values will be calculated and displayed on the right side of the surge window. The Maximum voltage reached for each lead's test will also be displayed on the right side of the window.
15. If the surge test data is satisfactory, press the Done button to return to the Motor Tree View.
16. In the Motor Tree View, either save the data or proceed with other tests. Usually, the surge test is the last test to be performed and the data should be saved now.
17. The Surge Test All Leads button will automatically sequence through Lead 1, Lead 2 and Lead 3 as if each button was pressed individually. The operator will only have to operate the Digital Tester.
18. After finishing surge testing of a motor, press the Done button in the upper right hand corner of surge test dialog window.

Saving & Reviewing Data

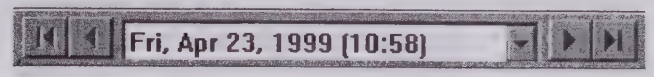
Saving Data

Once a test has been completed return to the **Motor Tree View**, the **Save Results** button will be highlighted. At this time save the results to the database or re-run the test. **NOTE: Test results must be saved prior to viewing them in the Results, PI, Surge and HiPot Views. Viewing unsaved test data may be done through the test dialogs.**

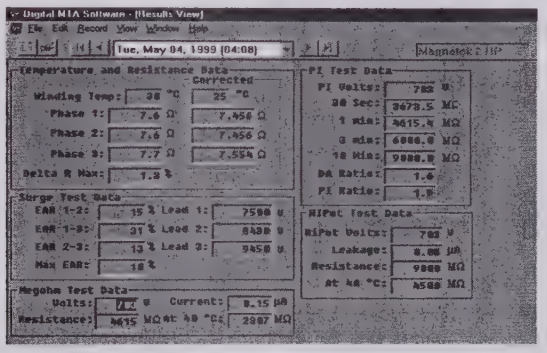
Results View

The **Results View** window is a display of the test results, which include Temperature and Resistance, Surge, Megohm, PI, and HiPot Test data.

Results from different tests can be read by scrolling through the record toolbar or selecting a test by the date/time. The record toolbar resides just below the menu options and is shown below:



The only test data that can be edited is Temperature and Resistance. On the edit menu there is a Re-Analyze Resistance option. When chosen, the Temperature and Resistance dialog will be displayed, allowing the user to enter new values and re-analyze. When complete, the user will be returned to the **Results View**. From here the new results may be saved.

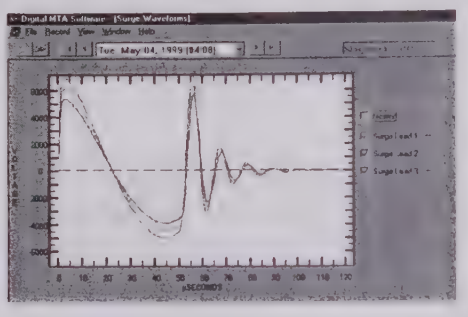


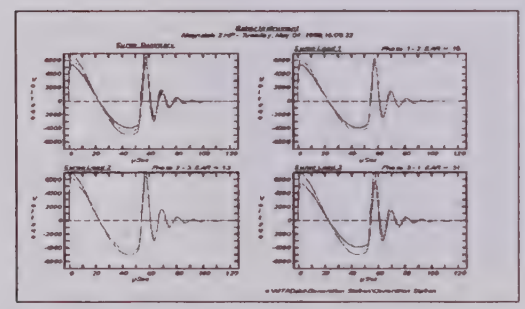
Surge View

The **Surge View** window is a display of the surge test results. Each lead may be viewed individually or in nested mode. In nested mode each lead contains three waves: (1/3) Target Voltage, (2/3) Target Voltage, and the full Target Voltage. Preview the printable surge report by selecting print preview option under file menu.

Do Not Touch Test Leads while test is in Progress!

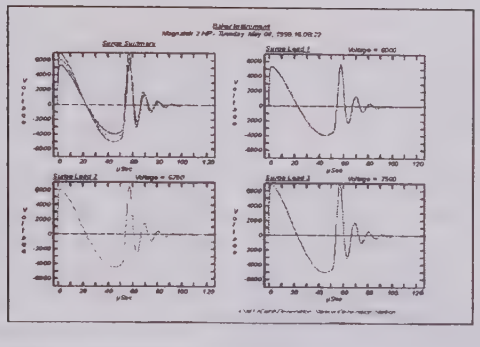
Two printable Surge Reports may be generated. The first Surge Report will display four graphs starting with the Summary. The Summary Graph displays all three leads at full target voltage. The second graph displays three waveforms from Lead 1 at (1/3), (2/3) and full voltage. The third graph displays three waveforms from Lead 2 at (1/3), (2/3) and full voltage, and the fourth displays three waveforms from Lead 3 at (1/3), (2/3) and full voltage.





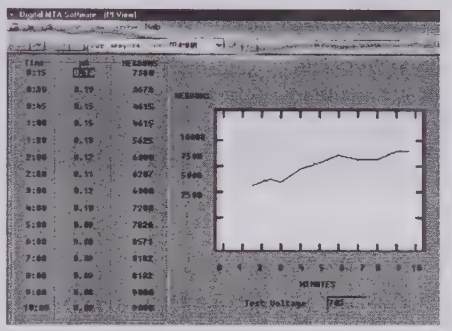
The second printable Surge Report displays four graphs also. The first graph is the same Summary Graph as above showing all three leads at the full target voltage. The remaining three graphs display the full voltage waveform from each lead in a comparison mode. The first comparison graph shows Lead 1 compared to Lead 2, the second comparison graph shows Lead 2 compared to Lead 3, and the last comparison graph shows Lead 1 compared to Lead 3. By displaying the waveforms from each lead on the same graph, differences between leads become readily apparent.

Do Not Touch Test Leads while test is in Progress!



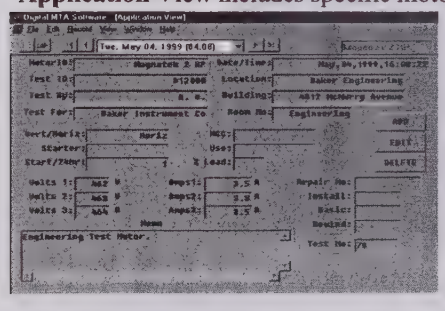
PI View

PI View window displays the PI values measured during the ten minutes PI test. Columns to the left list time, leakage current in microamps, and insulation resistance in Megohms. Megohms versus Time is plotted.



Application View

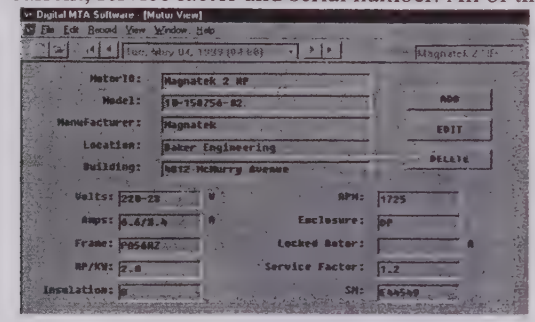
With every record of test data saved, an **Application View** is created. The **Application View** includes specific motor location, motor mounting details, starting and stopping information, operating conditions such as voltage and current draw per phase, and a user entered memo field. User entered fields on the **Application View** window may be edited and the memo field modified. The **Application View's** data may be included in the printed reports generated by MTA for Windows.



Do Not Touch Test Leads while test is in Progress!

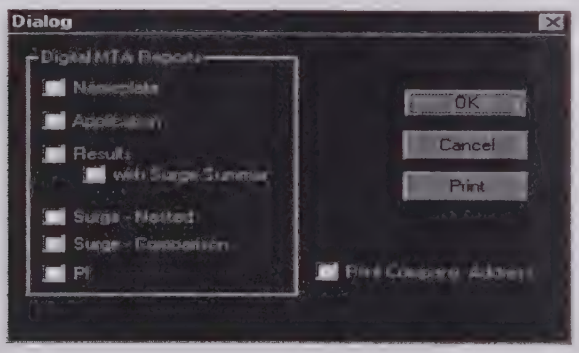
Motor View

Every motor has nameplate data that includes information provided by the motor manufacturer. Nameplate data includes operating voltage, operating current, shaft speed, frame type, power output (hp/kw), insulation type, locked rotor current, service factor and serial number. All of the above information may be entered on the **Motor View** for future reference completely documenting the type of motor being tested. The nameplate data may also be included in the printed reports generated by MTA for Windows.



Printing Reports

From any of the View screens, reports may be generated and printed on a printer attached to the computer. Individual, some, or all reports may be printed. If the computer being used has only one parallel port, the Digital Tester must be disconnected and the printer connected before printing reports.



A company name and address may be printed on the reports. Company information is entered from the **Motor Tree View** under the **File-Enter Company Information** menu item. The company information only shows if the Print Company Address option is checked when **Printing Selected Reports** – an option found under the **File** menu item on all of the views.

NOTE: For users of Windows NT, if the same parallel port is used for printing reports and communication with the Digital Tester, the printer will have to be reassigned to the parallel port. (See page 1 Configuring the PC's Parallel Port.)

Do Not Touch Test Leads while test is in Progress!

Do Not Touch Test Leads while test is in Progress!

SUPPLEMENT THREE: MODEL AT101D BAR-TO-BAR ARMATURE TEST ACCESSORY

Inside.....

- Operation
- Determination of a Fault
- Application Recommendations
- Specifications

Do Not Touch Test Leads while test is in Progress!

Do Not Touch Test Leads while test is in Progress!

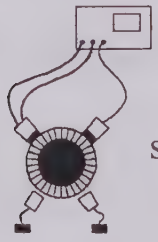
Model AT101D Bar-to-Bar Armature Test Accessory

The model AT101D Bar-to-Bar Armature Test Accessory is an adapter which converts any Baker Instrument Company surge tester with an output of up to 15 kV into a low impedance, high current, bar-to-bar armature tester. The bar-to-bar test method is recognized as superior to the span test method for testing armatures.

To illustrate the difference between the bar-to-bar and span tests, consider this example. A manufacturer of lap wound elevator motor armatures determines that, to thoroughly test the turn-to-turn and coil-to-coil insulation, a test voltage of 400 volts across each coil is required. However, the impedance of a single coil in the armature is so low that it appears as a dead short to a conventional surge tester designed for testing AC stators. Even with the hefty current of a 12 kV surge tester, only a few hundred volts may be generated into such a load. Most of this voltage is actually lost in the test leads of the surge tester. Consequently, the span test was developed (see figure below).

In the span test, the test contacts are placed several bars apart, so that the impedance of several coils is large enough to be tested with the surge tester. For example, to generate 400 volts across each coil of a 10 bar span, the test voltage must be increase to 4000 volts. However, 4000 volts at the high voltage contacts delivering the surge test will over-stress and probably damage the ground insulation at the first coil in series. Therefore, the maximum test voltage must be decreased to the same level as the safe DC HiPot voltage for that motor, or about 2000 volts. Now the coils are not adequately being tested, since the bar-to-bar voltage is only 200 volts.

In a bar-to-bar surge test, 400 volts is applied directly to each coil without over-stressing the ground insulation (see figure below). The AT101D Bar-to-Bar Testing Accessory provides a specially designed low output impedance surge tester with low impedance test leads to make this test possible.



Span Test

Bar-to-Bar Test

Do Not Touch Test Leads while test is in Progress!

The AT101D, when connected between a surge tester and an armature, converts the surge tester output from high voltage to lower voltage with high current. This is necessary for bar-to-ar armature testing of low impedance coil windings. The AT101D contains a high energy pulse transformer which steps down the surge tester voltage by a factor of 10 and inceases the current by a factor of 10.

The basic procedure involves connecting the surge tester output leads to the input of the AT101D. The output of the AT101D travels through a low impedance cable assembly and armature contactor. The bar-to-bar output voltage is monitored by a peak-hold voltmeter in the AT101D. The surge test wave pattern and test voltage are displayed concurrently on the surge tester CRT screen. Test voltage is measured directly at the contactor, so there is no measurement error from test lead losses.

When a faulty coil is detected, the output voltage on the peak voltmeter willd rop dramatically. A corresponding collapse in the amplitude and left shift of the surge test wave pattern will be evident. This is easily simulated by shorting the two bars under test with a screwdriver. In fact, the AT101D will detect shorted bars that are four or five bars away from the bars under test.

Operation

Note: The AT101D must show on its rear panel that it has been set up and calibrated for the specific surge tester you are using.

1. Turn the surge tester OUTPUT control to MIN.

2. Make the appropriate connections between the AT101D and the surge tester.

    a. The interconnect cable between the AT101D and surge tester is a 25-pin RS232 D-type connector. Connect this cable to the front panel of the AT101D and to the port on the surge tester, each marked AUX.

    b. Select a numbered Test Lead Select (TLS) witch position on the surge tester. The following table indicates the state of each of the tester leads for any given numbered TLS position.

Switch Position	Test Lead #1	Test Lead #2	Test Lead #3	⏚ - Ground
TLS 1	Hot	Ground	Ground	Ground
TLS 2	Ground	Hot	Ground	Ground
TLS 3	Ground	Ground	Hot	Ground
All Leads Ground	Ground	Ground	Ground	Ground

c. Use the table above to determine which surge tester red lead is Hot. Connect this lead to the recessed bar on the back of the AT101D labeled Hot Lead.

d. Use the table above to determine which surge tester red lead is Ground. Connect this lead to the recessed bar on the back of the AT101D labeled Ground Lead.

e. Lay the remaining surge tester red Ground leads aside.

f. The black surge tester Ground lead must be connected to the armature iron. If testing single low impedance coils using ATPO2 alligator clips or test probes, connect the surge tester Ground lead to the core material.

Note: When using alligator clips or test probes on armatures that have bars that are wired in series, it is very important to ground at least two bars of the armature a few bars away from those that are being surged. If this is not done, very high potential voltages to ground can develop in the armature due to a transformer effect in the coils.

3. Turn the Function knob of the surge tester to AT101D.

4. Connect the armature test fixture to be used (the hand-held contactor, test probes, or test alligator clip) to the blue braided harness. (Instructions that follow wil be for the hand held contactor.) The black cover may be removed to access the brushes and shape tham as necessary for best contact.

5. Place the AT101D contactor on the armature commutator, making sure the contact brushes are on adjacent bars, not the same bar.

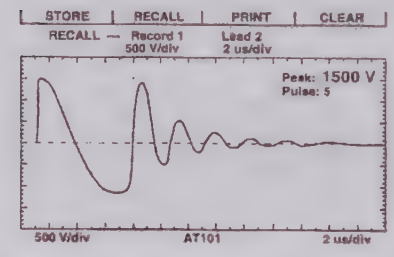
6. Press the surge tester Test (or depress the Footswitch) and raise the Output control slowly. A wave pattern and its corresponding peak voltage shoule be visible on the surge tester screen. Adjust the Output control until the desired bar-to-bar voltage is reached.

Note: The Zero Start Interlock (ZSI) can be disabled to more conveniently perform this test. On the Digital Surge Tester, position the Function switch to AT101D and depress the Footswitch to automatically disable the ZSI.

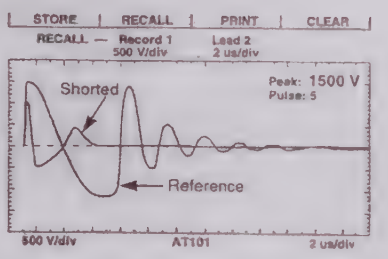
7. The true test peak voltage is correctly measured from the surge tester display as the contactor head is moved around the commutator. As each bar is tested, the result may be stored in internal memory (refer to Storage and Print Capabilities).

Determination of a Fault

As the contactor approaches a shorted pair of bars, the waveform becomes increasingly distored, shifting left and with lower amplitude. The test brushes are over the faulty, shorted bars when the waveform amplitude is lowest. Faulty bars are read through the equalizers but the amplitude of the waveform will not be as low as when the test brushes are directly contacting the actual bad bars.



Good bar-to-bar surge test.



Contactor over the bar with shorted windings as compared to good winding.

Note: A slight, regular rhythmic shift may be observed when testing an armature. This is generally due to the equalizer windings and can be ignored. Hard shorted turns or insulation breakdown will be evident by an obvious change in the surge test wave pattern.

When testing coils with ATPO2 alligator clips, a fault should be interpreted in one of two ways.

1. A single coil should be tested by observing the wave pattern from zero volts up to the desired test voltage level. A coil with good insulation will show

the same wave pattern at increasing voltage levels. A fault will show by the collapse of the amplitude and a shift to the left of the wave pattern.

2. A group of single coils may be tested by examining and recording a known good coil first.

    a. Using the good coil, adjust the display controls to obtain the desired wave pattern on the display to be used as the reference wave pattern. Store the pattern in memory if using a digital tester. Use Quick Store to immediately recall this reference wave pattern back to the screen.

    b. Leave all surge tester controls unchanged or record these reference settings. Begin testing on the other coils. The other coils surge test wave patterns should fit very closely to that of the first coil if they are in good condition. A shorted coils patter will be collapsed and shifted left of the pattern of the reference coil.

Application Recommendations

- Most armatures requiring the use of an AT101D will be tested to at least 350 volts bar-to-bar.

- It is recommended that Baker Instrument Company 6 kV model surge tester be used with the AT101D only for special applications which do not exceed 300 volts. This is quite common for lift truck armatures.

- Armatures which require bar-to-bar test voltages up to 600 volts should use Baker Instrument Company 12 kV model surge testers with the AT101D.

- Very large armatures, such as diesel locomotive traction motor armatures, require testing up to 750 volts bar-to-bar. These necessitate at least a 15 kV Baker Instrument Company surge tester used in conjunction with the AT101D. Alternatively, a Multiple Tester from Baker Instrument Company may be required. Please contact us for information regarding stand alone high power armature surge and HiPot testers for large AC and DC motor work, especial heavy rail tractions motors.

- A 24 kV tester may be used with the AT101D. Its output should be limited so that the peak voltage measurement on the AT101D never exceeds 950 volts.

Specifications for the AT101D Bar-to-Bar Armature Testing Accessory

Surge Input - Maximum Voltage:	15,000 volts peak.
Testable Inductance Range:	0.4 to 20 micro-henries (μh)
Cable and Test Head Inductance:	1.0 micro-henries (μh)
Transformer Turns Ratio:	10:1
Observed Voltage Step-down:	10:1 for test load of 5 micro-henries (μh) Or greater 20:1 for 1 micro-henries (μh) load

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